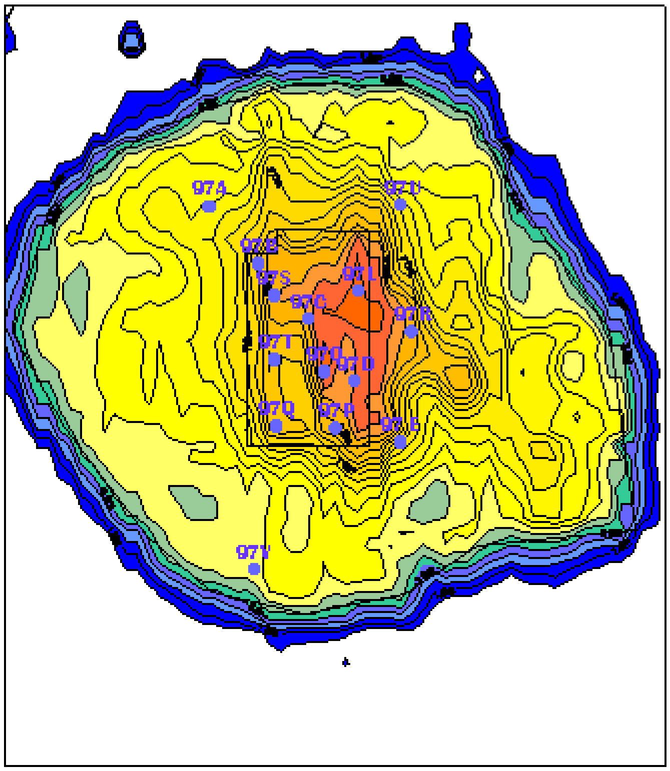
THE 1997 CATEGORY II CAPPING PROJECT AT THE NEW YORK MUD DUMP SITE: SUMMARY OF GEOTECHNICAL AND CHEMICAL ANALYSES FROM THE MAY 1999 ONE-YEAR POSTCAP VIBRACORING SURVEY



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February 2000

Delivery Order No. 18 of Indefinite Quantity Contract No. 49

USACE Contract No. DACW51-97-D-0014
SAIC Project No. 01-0440-04-1994-400
Report No. 94 of the New York Mud Dump Site Studies
SAIC Report No. 475

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ACKNOWLEDGMENTS

This report presents the results of the May 1999 one-year postcap sediment coring survey for the 1997 Category II Capping Project at the New York Mud Dump Site. This survey was conducted by Science Applications International Corporation (SAIC) of Newport, RI, under contract to U.S. Army Corps of Engineers - New York District (NYD). Dr. Stephen Knowles is the NYD's manager of technical activities; Dr. Scott McDowell is SAIC's program manager.

Dr. Knowles provided logistical and planning support for the survey, with assistance from Mr. Tim LaFontaine of the NYD's Caven Point facility. Dr. Knowles and Mr. Michael Harris (NYD) provided technical review comments on the draft report.

The following SAIC staff participated in the coring survey: Messrs. Ed DeAngelo, Jason Infantino, Ms. Kate Pickle, and Ms. Melissa Swanson. SAIC staff was responsible for DGPS navigation, selection of coring stations, and handling/custody of core samples.

Ocean Surveys, Inc., under subcontract to SAIC, was responsible for providing vibracoring equipment and an experienced coring technician, Mr. Kevin Murphy.

Survey operations were conducted aboard the NYD's M/V *Gelberman*. The crew of the M/V *Gelberman* is commended for their skill in vessel handling while conducting coring operations, as well as their dedication during long hours of operation at the Mud Dump Site.

Core processing was conducted at GeoTesting Express' laboratory in Boxborough, MA. SAIC staff was responsible for core splitting, descriptions, photography, and chemical sampling were Ms. Pickle, Ms. Swanson, and Mr. Infantino. GeoTesting Express, under subcontract to SAIC, was then responsible for the geotechnical analyses of the sediment core samples.

Pace Analytical Services, Inc. of St. Paul, MN, (formerly Maxim Technologies, Inc.) conducted the chemical analyses of sediment core samples.

Ms. Pickle and Ms. Swanson prepared this report. Ms. Peggy Myre and Mr. Ray Valente provided technical review of the report, while Mr. Tom Fox was responsible for report production.

1.0 INTRODUCTION

This report summarizes geotechnical and chemical data from cores collected at the New York Bight Dredged Material Disposal Site (former Mud Dump Site) in May 1999, as part of a series of one-year postcap surveys for the 1997 Category II Capping Project. The results represent the fifth geotechnical survey and the second set of chemical data from sediment cores for this project. The specific objectives of this coring survey were: to evaluate changes in the geotechnical properties of the project material since the initial postcap coring survey in April 1998, to evaluate the consolidation of the project dredged material since the placement of cap material at the site, and to evaluate the effectiveness of the sand cap in isolating chemical contaminants known to be present in the underlying dredged material.

Core locations, core logs and descriptions (Appendix A), discrete geotechnical sample data from GeoTesting Express (Appendix B), down-core profiles of water content and bulk density (Appendix C), and all chemical analysis data from Pace Analytical Services will be available through the Disposal Analysis Network - New York (DAN-NY) information management system.

1.1 Background

Sediments dredged from the Ports of New York and New Jersey have historically been placed at an ocean disposal site in the New York Bight formerly known as the Mud Dump Site (MDS). This site, located six nautical miles off the coast of Sandy Hook, NJ, is a 2.2 square mile rectangular area in approximately 12-27 m of water (Figure 1-1). In response to growing concerns about site capacity and the environmental effects of dredged material disposal, a decision was made in 1996 to close the MDS by September 1, 1997. On August 26, 1997, the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers finalized the rule providing for closure of the MDS. Simultaneously, the site and surrounding areas, which have been used historically for disposal of dredged material, were re-designated as the Historic Area Remediation Site (HARS). The locations of the former MDS and the HARS are shown in Figure 1-1.

The planned closure of the MDS on September 1, 1997, left the Port Authority of New York and New Jersey (PANYNJ) with a limited period of time to dispose of a finite volume of dredged material with a potential for bioaccumulation (i.e., Category II) at the site, and cover these sediments with a layer of clean (i.e., Category I) sediment. A plan was developed in early 1997 to address dredging, ocean disposal, and subsequent capping of the Category II material at the MDS prior to the September 1 closure. This capping project is referred to as the 1997 Category II Capping Project.

The Category II project material was dredged from selected berthing facilities in Newark Bay, New Jersey. Placement of this material within the southeast quadrant of the MDS (Figure 1-2) began in late May 1997 and continued until August 10, 1997. During this period, approximately 700,000 yd^3 of material were disposed, creating a distinct mound on the bottom. Immediately following the completion of the placement operation, capping of the project material with 2.4 million cubic yards of clean sand from Ambrose Channel began on August 21, 1997. The capping operation continued intermittently until January 18, 1998, when it was demonstrated that a 1-m thick layer had been placed over the entire project material footprint.

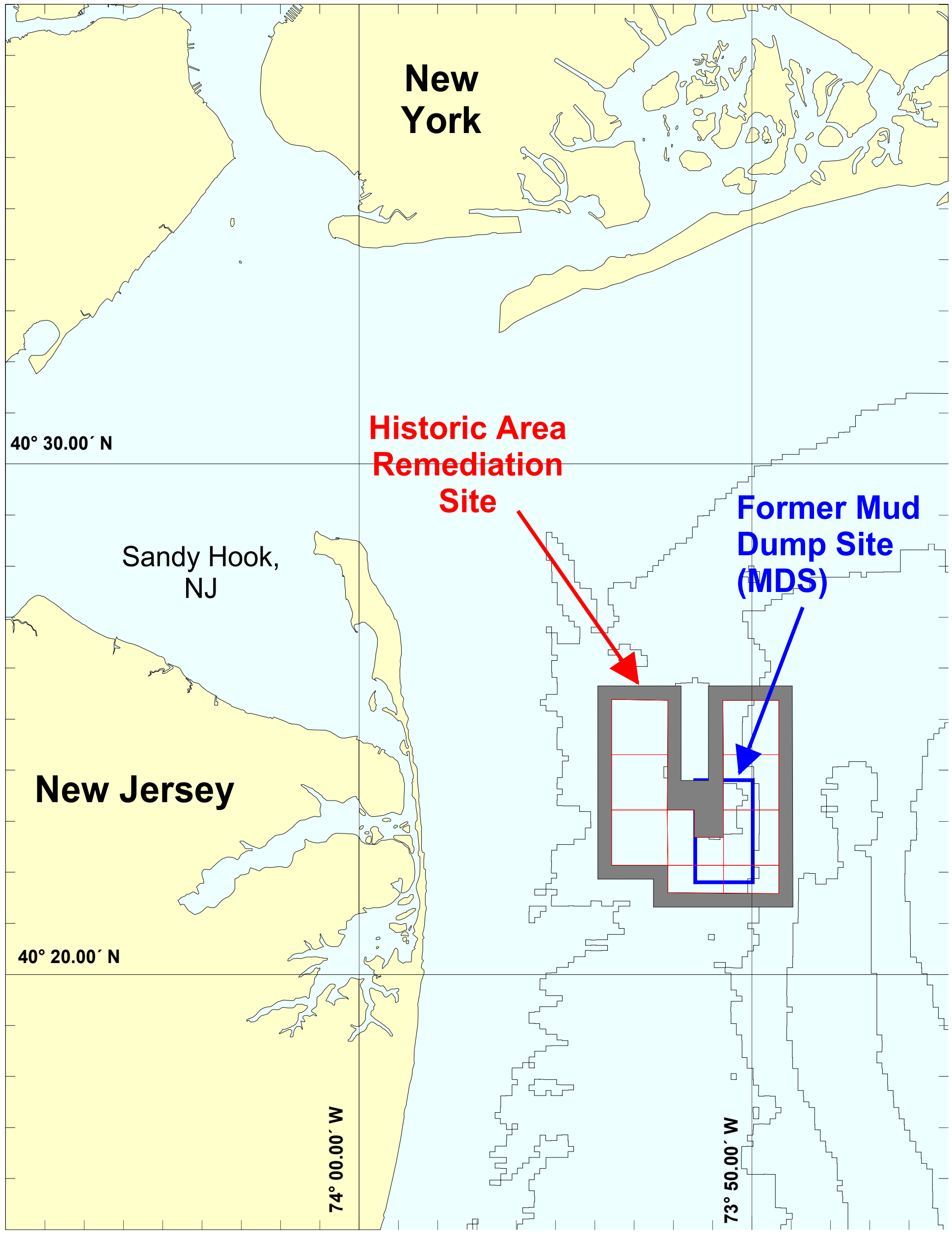

Figure 1-1. Locations of the former Mud Dump Site (MDS) and the Historic Area Remediation Site (HARS) in the New York Bight.

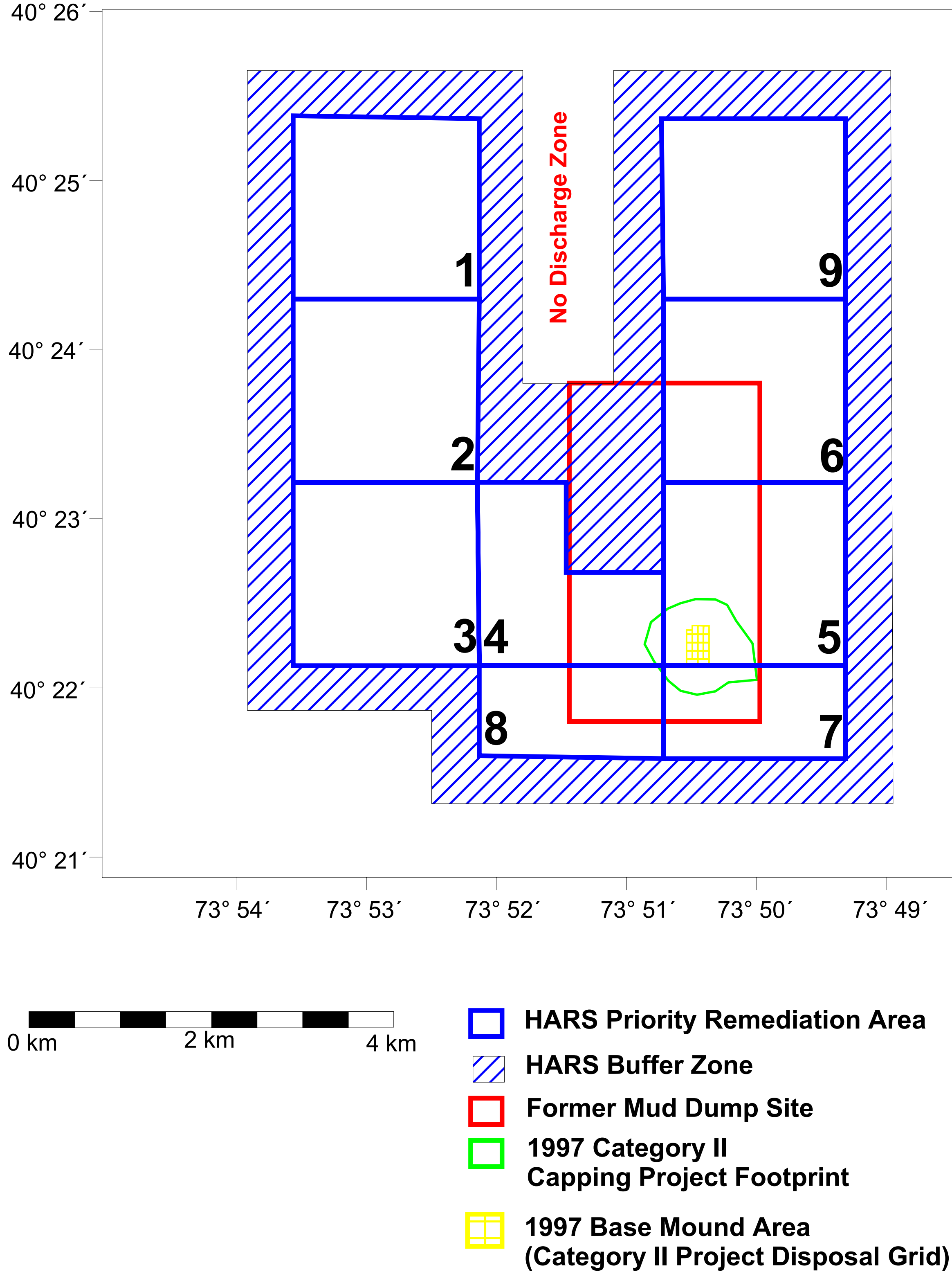

Figure 1-2. Map showing the HARS, former MDS, and footprint of the 1997 Category II Capping Project within the southeast quadrant of the former MDS.

As part of this project, the NYD contracted SAIC to collect data on seafloor characteristics in the area of the MDS selected for placement of the Category II material. Data were collected prior to placement of the dredged material, as well as during and immediately following both the disposal and capping operations (Figure 1-3). The following monitoring techniques were utilized: high-resolution bathymetry, seafloor video reconnaissance, chemical analysis of surface sediment and biological tissue samples, sediment coring, subbottom profiling, and REMOTS® sediment-profile imaging. The data provided information about the thickness and distribution of both the dredged material and sand cap, and was used to assess the impacts of the capping project on benthic habitat quality and recolonization.

This report presents the results of the one-year postcap coring survey for the 1997 Category II Capping Project. This survey was conducted aboard the NYD's M/V *Gelberman* in May 1999. One-year postcap bathymetric and REMOTS® surveys also were conducted for the NYD to detect any changes in the seafloor topography of the capped project mound, and to assess changes in benthic habitat quality and recolonization. The results of these surveys are presented in a single report under a separate delivery order (SAIC 1999).

1.2 Survey Objective

The primary objective of the one-year postcap coring survey was to acquire sediment vibracores, 6 to 10 feet in length, at each of the 14 stations shown in Figure 1-4. At seven of the stations, a duplicate core was obtained and shipped to the U.S. Army Corps of Engineers Waterways Experiment Station (WES) for analysis of geotechnical and consolidation properties of the in-place sand cap and underlying dredged material. The complete set of 14 cores was analyzed by SAIC, and the results are presented in this report.

Based on observations from the 1993 Dioxin Capping Monitoring Project, as consolidation of the project material begins to occur, changes in material properties (e.g., lower water content, increased bulk density, decreased void ratio) are expected (SAIC 1998a). The dataset compiled from this and previous coring surveys for the 1997 Category II Capping Project, therefore, will serve to help monitor physical changes in the project material and enhance long-term understanding of the consolidation process. Data collected in this survey about the material's chemical characteristics will be compared to that collected in the April 1998 postcap survey (SAIC 1998b). This comparison will serve to assess and further understand the long-term effectiveness of using a sand cap as a technique for isolation of dioxin-contaminated sediments.

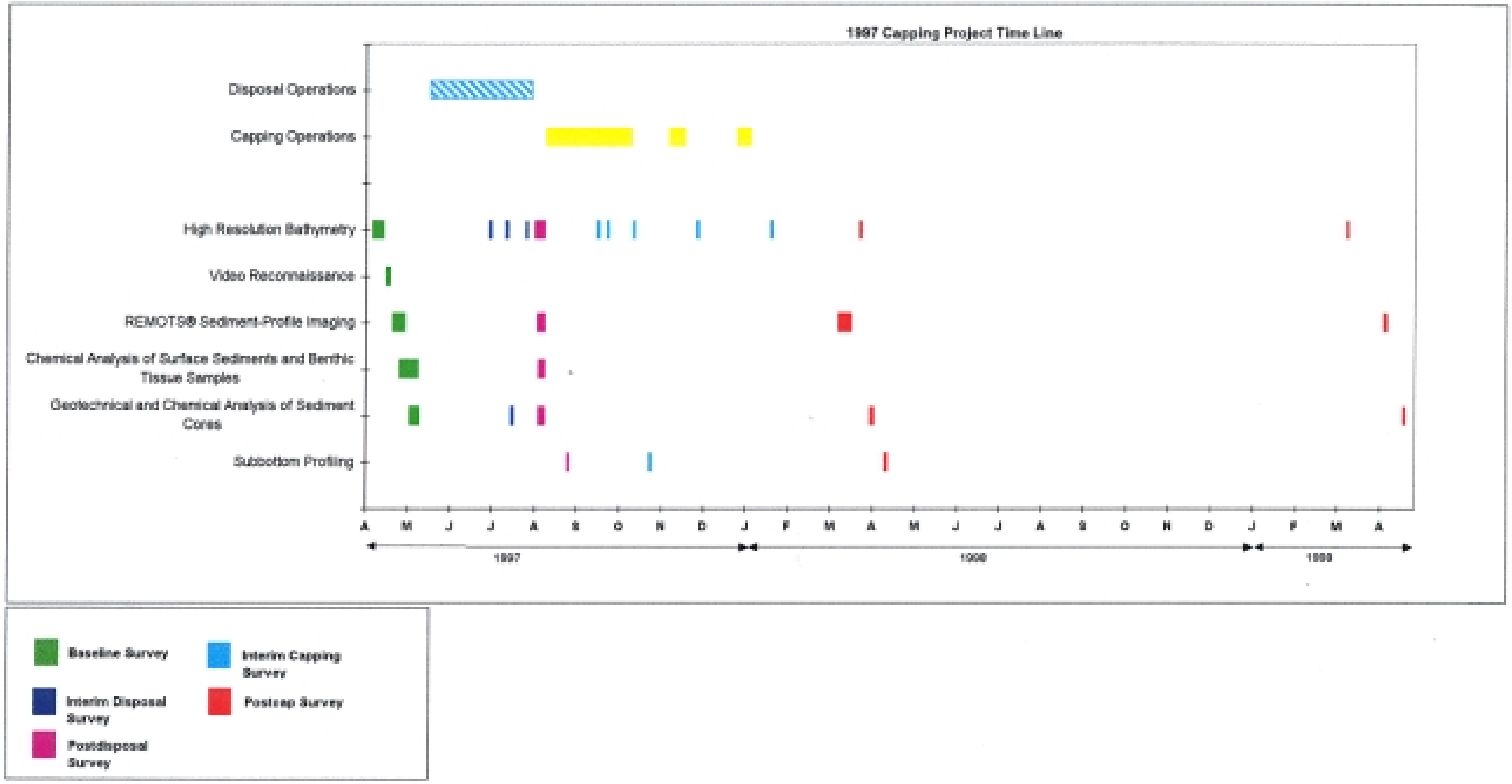

Figure 1-3. 1997 Category II Capping Project time line.

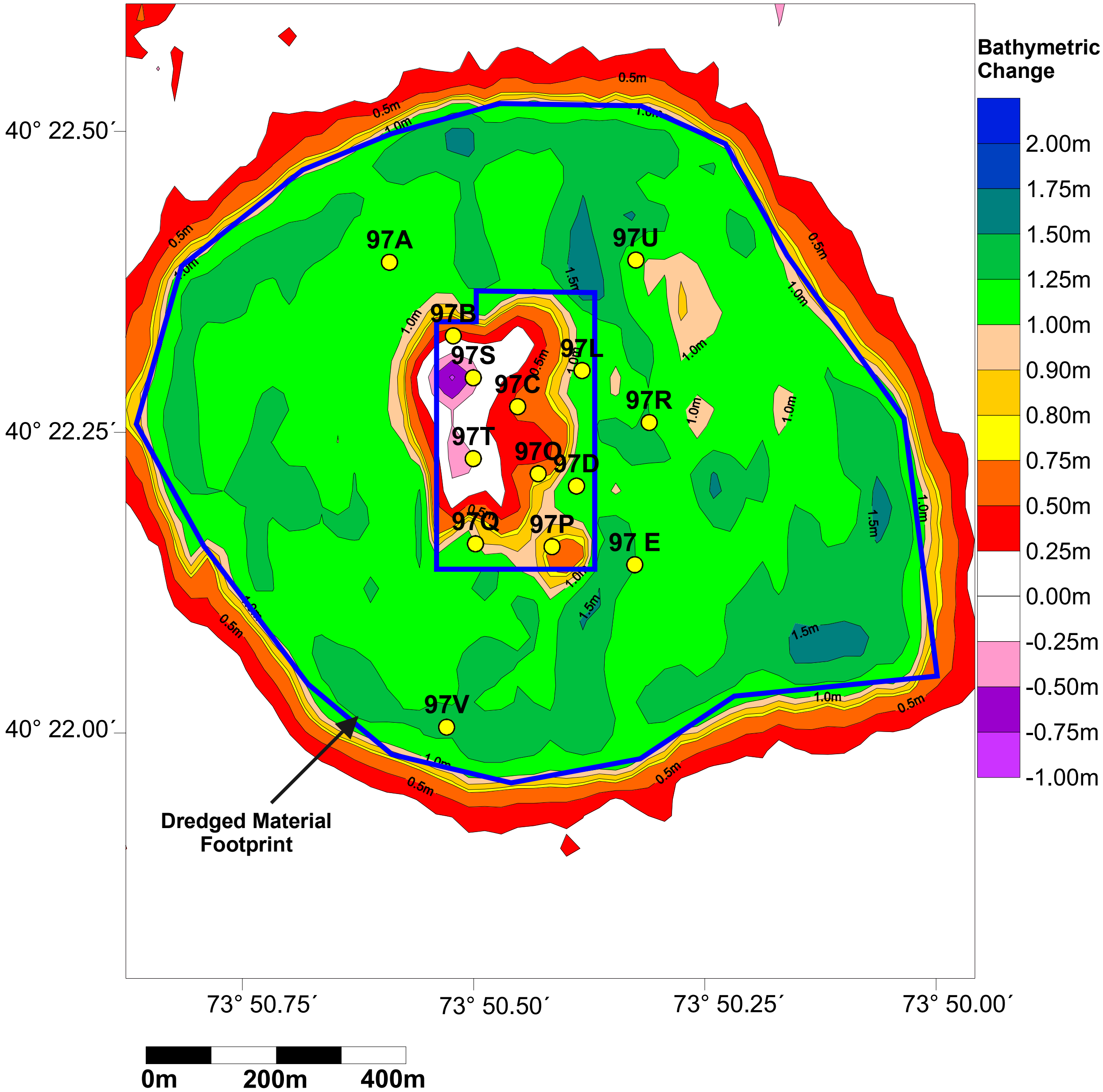

Figure 1-4. Map showing station locations of core samples obtained during the May 1999 one-year postcap coring survey. Bathymetric results are based on the depth difference between the postdisposal (August 1997) and one-year postcap (April 1999) bathymetric surveys. The negative values in the center of the mound are due to a slope shift that occurred between the August 1997 and April 1999 bathymetric surveys.

2.0 METHODS

2.1 Station Selection and Locations for Geotechnical Surveys

Station locations for the series of geotechnical coring surveys (baseline, interim disposal, postdisposal, and postcap) were selected to optimize sampling of the placed dredged and cap material. For the baseline coring survey, performed in May 1997, 11 stations were located along a northwest-southeast transect crossing the center of the target disposal area (1997 Base Mound Area) to give an overview of predisposal conditions in this region (Figure 2-1; SAIC 1998c). Five of these baseline stations (97A-97E) were re-occupied during the interim, postdisposal, postcap, and one-year postcap coring surveys.

Based on the results of the first interim disposal bathymetric survey of July 11, 1997 (SAIC 1997a), an additional seven stations were selected for the interim disposal coring survey to sample the apex of the mounds formed by the disposal operations. During the postdisposal coring survey, four of the newly selected interim disposal coring stations (97L, 97O, 97P, and 97Q) were re-occupied, and another three stations were added, based on depth differencing results between the third interim (August 6, 1997) and baseline bathymetric surveys (SAIC 1997b). Figure 2-2 shows the location of the 12 stations sampled during the postdisposal coring survey, in relation to the dredged material layer thickness as of the August 1997 postdisposal bathymetric survey. One of the three newly added stations for the postdisposal survey (97R) was located outside the Base Mound Area to sample material redistributed by the eastern mound slope adjustment (SAIC 1997b). The remaining two stations (97S and 97T) were positioned at the apex of the newly formed mounds observed on the western side of the Base Mound Area.

For the first postcap survey (April 1998), all 12 of the postdisposal coring stations were reoccupied. Two additional stations, 97U and 97V, were added to increase the mound coverage and to better examine areas where material was redistributed during the postdisposal slope adjustment on the western side of the Base Mound Area (SAIC 1998d). These same 14 stations were again occupied during the present survey, and their locations are shown in Figure 1-4 in relation to sand cap thickness as measured in the May 1999 one-year postcap bathymetric survey (SAIC 1999).

2.2 Field Operations

The one-year postcap sediment coring survey was conducted aboard the NYD's M/V *Gelberman* during May 11-12, 1999. One sediment core was collected at each of the 14 stations shown in Figure 1-4, and later delivered to GeoTesting Express in Boxborough, MA, by SAIC. Additionally, a duplicate core was obtained at seven of the stations and shipped by the NYD to the WES laboratories in Vicksburg, MS. Table 2-1 presents a complete listing of all 21 cores obtained.

Vessel positioning and data integration were achieved with SAIC's Portable Integrated Navigation Survey System (PINSS). The PINSS utilized a Toshiba 3200DX personal computer to provide real-time navigation, as well as to collect position, depth, and time data for subsequent analyses. Vessel positioning at predetermined stations was accomplished using a Trimble GPS

Table 2-1

Sediment Cores Acquired During the May 1999 One-year Postcap Coring Survey

Cores provided to GeoTesting Express						
Survey Identifier	**Core**	**Replicate**	**Latitude (N)**	**Longitude (W)**	**Acquired Date**	**Length (cm)**
0599	97A	B	40° 22.393'	73° 50.589'	5/11/99	293.1
0599	97B	B	40° 22.332'	73° 50.520'	5/11/99	279.2
0599	97C	B	40° 22.273'	73° 50.450'	5/11/99	281.7
0599	97D	B	40° 22.207'	73° 50.387'	5/11/99	291.9
0599	97E	A	40° 22.142'	73° 50.324'	5/12/99	266.5
0599	97L	B	40° 22.303'	73° 50.381'	5/11/99	266.5
0599	97O	A	40° 22.217'	73° 50.428'	5/12/99	281.7
0599	97P	A	40° 22.157'	73° 50.413'	5/12/99	289.3
0599	97Q	A	40° 22.159'	73° 50.496'	5/12/99	264.0
0599	97R	B	40° 22.260'	73° 50.308'	5/11/99	238.6
0599	97S	B	40° 22.297'	73° 50.498'	5/11/99	284.3
0599	97T	A	40° 22.230'	73° 50.498'	5/12/99	283.0
0599	97U	A	40° 22.395'	73° 50.323'	5/11/99	277.9
0599	97V	B	40° 22.007'	73° 50.527'	5/12/99	238.6
Core replicates sent to WES						
Survey Identifier	**Core**	**Replicate**	**Latitude (N)**	**Longitude (W)**	**Acquired Date**	**Length (cm)***
0599	97A	A	40° 22.393'	73° 50.589'	5/11/99	264.0
0599	97B	A	40° 22.331'	73° 50.518'	5/11/99	283.0
0599	97C	A	40° 22.273'	73° 50.450'	5/11/99	280.5
0599	97D	A	40° 22.207'	73° 50.387'	5/11/99	302.0
0599	97R	A	40° 22.260'	73° 50.306'	5/11/99	241.1
0599	97S	A	40° 22.296'	73° 50.500'	5/11/99	291.9
0599	97U	B	40° 22.396'	73° 50.323'	5/11/99	288.1

Coordinates in NAD 83

*WES cores greater than 175 cm were cut into two pieces for shipping purposes (see text).

positioning system interfaced with the PINSS. One- to five-meter accuracy was achieved by applying a differential correction to the GPS signals, which were acquired from the US Coast Guard broadcast station located at Sandy Hook, NJ. Vessel position was displayed on two monitors, one for the survey navigator and the second for the helmsman, to aid in steering the vessel toward target station locations. Each fix incorporated time of day, the vessel's position in latitude and longitude and UTM coordinates, signal quality, and station and replicate identification. The survey vessel was anchored, in a 2-point configuration, during all coring operations. Differential GPS navigation data were received, logged, and displayed in the North American Datum 1983 (NAD 83) geographic coordinate system.

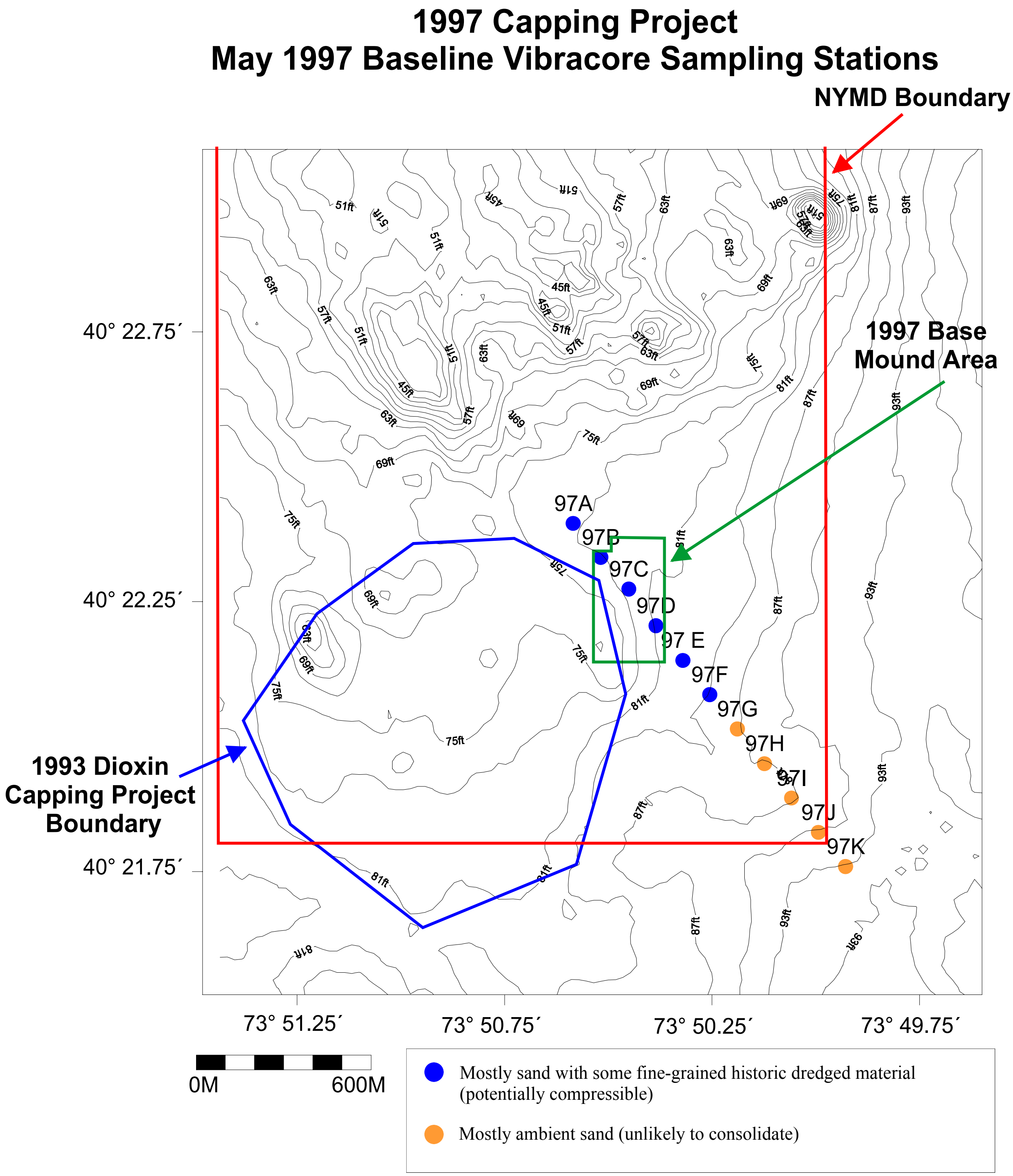

Figure 2-1. Vibracore stations occupied during the May 1997 baseline survey.

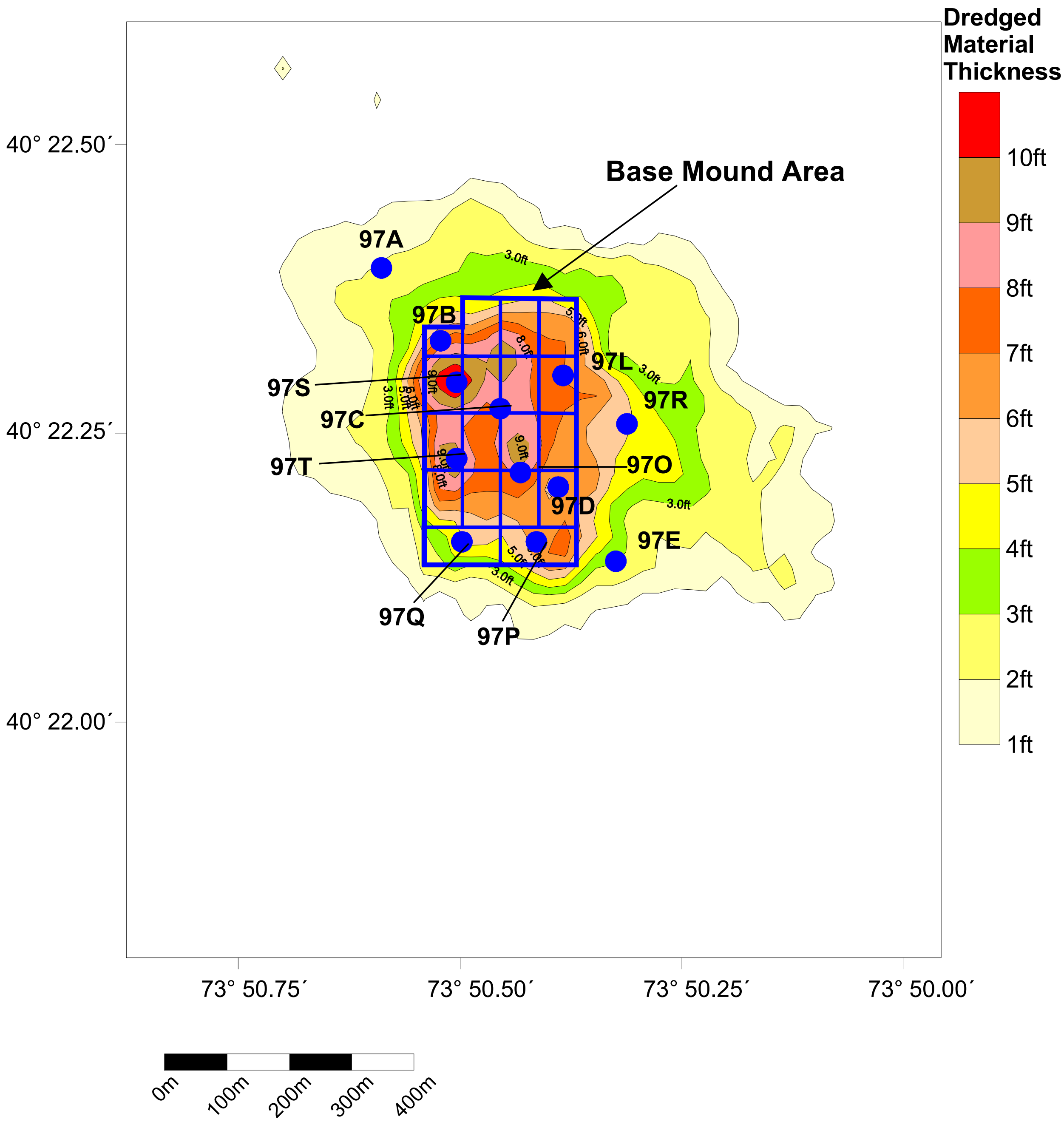

Figure 2-2. Postdisposal core locations superimposed on bathymetric results showing dredged material thickness based on the depth difference between the baseline (April 1997) and postdisposal (August 1997) bathymetric surveys.

An Ocean Surveys, Inc. Model 1500 vibracorer, with an internal diameter of 3-1/2 inches, was used to acquire the sediment core samples. This device was selected because of its demonstrated ability to acquire sediment core samples of at least 2 m in length on sand-capped mounds within the Mud Dump Site. Immediately following retrieval of the vibracoring device at each station, the core liner was removed from the barrel and carefully capped with a Styrofoam plug and core cap to prevent loss of sediment and/or water. The core was then marked with a unique station identifier that included the month and year of the survey (e.g., 0599), the station name, and the replicate (e.g., A or B). The cores were stored horizontally in an iced cooler aboard the survey vessel. Cores remained refrigerated aboard the vessel throughout the survey and during transportation to and analysis procedures at, GeoTesting Express.

The seven replicate cores collected for WES were delivered to NYD personnel at Caven Point for eventual shipment, in a vertical position, in a container provided by WES. This container was not large enough to accommodate the entire core length; therefore, cores were cut approximately 175 cm from the core base (with the exception of Cores 0599-97A-A and 0599-97R-A, discussed below). This resulted in cuts being made within the sand cap layer, and ensured that the sand cap-dredged material interface remained undisturbed. In the case of Cores 0599-97A-A and 0599-97R-A, cutting in this manner would have resulted in the cores being separated near the interface. In these two cases, it was decided to cut the core 175 cm from the core top (within the dredged material; DM) to ensure an undisturbed interface.

2.3 Core Processing

Cores were transported horizontally in an ice filled cooler to GeoTesting Express on May 13, 1999. In the laboratory, all 14 cores retained by SAIC were split, visually described, digitally photographed, and sampled for chemical analysis. Geotechnical analyses were then performed on all 14 cores by the technicians at GeoTesting Express. Geotechnical analyses included water content, bulk density, grain size, Atterberg limits, and specific gravity. Void ratios were calculated from the geotechnical data for each sample by SAIC.

2.3.1 Core Splitting

Each core tube was scored horizontally using an inverted radial arm saw. Care was taken to cut only the core tube and not the enclosed sediment. The scored core was then transferred to a laboratory bench and the thin layer of remaining core tube cut using a utility knife. Next, a thin wire was used to split the sediment axially into two halves. This is a delicate process requiring two people with spatulas to assure that the two halves are maintained in an essentially undisturbed condition. The wire was drawn from the top of the core to the bottom to avoid mixing any potential chemical contamination of the cleaner cap sediments by the underlying project material. One half-section was used for detailed visual description, photography, and chemical analysis sampling. The remaining half was processed for geotechnical analyses.

2.3.2 Core Descriptions and Photography

After splitting, each core was carefully examined and described in detail by SAIC personnel. The split cores were photographed with an Olympus D500L digital camera mounted on a copy stand equipped with daylight-balanced lights. The focal distance was kept constant so that individual photographs could be pieced together to form a continuous view of the core. In order to document core features and penetration depth in successive images, a centimeter scale was affixed to the core crib, which held the core half during photographing. The descriptions and photographs were then combined to create a log for each core; the core logs are presented in Appendix A of this report.

2.3.3 Core Sampling

Cores were sampled for both geotechnical and chemical analyses beginning on May 17, 1999. Geotechnical analyses included measurements of water content, bulk density, grain size (sieve and hydrometer), Atterberg limits, and specific gravity. Chemical analyses included measurements of PCDD/PCDFs (i.e., dioxins and furans), total organic carbon (TOC), and percent moisture. Table 2-2 summarizes the type of analyses performed on each core retained by SAIC.

2.3.3.1 Geotechnical Sampling

The number of samples it was possible to obtain from each core varied depending upon the amount of material recovered.

A maximum of 20 samples were taken from each core for the determination of water content and bulk density. These samples were taken side-by-side across the width of the sampled core half at equidistant intervals based on each core's length. Up to five samples for each analysis came from the sand cap, while the remaining 15 were from the underlying, finer-grained, dredged material. For quality control of water content analyses, triplicate samples were taken at one sample interval in the sand cap (Core 97B-B) and one sample interval in the dredged material (Core 97C-B).

Up to two samples were obtained from the sand cap of each core for grain size analysis by sieve, and up to five samples were obtained from the dredged material unit for analysis by both sieve and hydrometer methods. Samples were taken at equidistant intervals based on the length of each layer. For the purpose of quality control, triplicate analyses were performed on one section of each layer (cap material: Core 97B-B; DM: 97C-B).

Up to three samples for Atterberg limits were obtained from each core for analysis using a wet sample preparation. Samples were collected from homogenous (unmottled) areas of fine-grained material within the length of the core, at intervals left to the discretion of the laboratory technicians.

Three samples were obtained from the dredged material of each core for the analysis of specific gravity. The location of these samples was left to the discretion of the laboratory technicians.

Table 2-2

Sediment Core Station Locations, Analyses Performed, and Length of Cores Collected

Core	Analyses			Length	Latitude (N)	Longitude (W)
	visual	geotechnical	chemical	(cm)	NAD 83	
97A-B	x	x		285.0	40° 22.393'	73° 50.589'
97B-B	x	x	x	268.5	40° 22.332'	73° 50.520'
97C-B	x	x	x	272.0	40° 22.273'	73° 50.450'
97D-B	x	x		279.0	40° 22.207'	73° 50.387'
97E-A	x	x	x	258.0	40° 22.142'	73° 50.324'
97L-B	x	x		257.0	40° 22.303'	73° 50.381'
97O-A	x	x		271.0	40° 22.217'	73° 50.428'
97P-A	x	x		285.0	40° 22.157'	73° 50.413'
97Q-A	x	x	x	259.0	40° 22.159'	73° 50.496'
97R-B	x	x	x	230.0	40° 22.260'	73° 50.308'
97S-B	x	x		273.0	40° 22.297'	73° 50.498'
97T-A	x	x		275.0	40° 22.230'	73° 50.498'
97U-A	x	x	x	268.0	40° 22.395'	73° 50.323'
97V-B	x	x		229.0	40° 22.007'	73° 50.527'

2.3.3.2 Chemical Sampling

A total of 30 samples were taken from six of the 14 cores for chemical analysis of PCDDs, PCDFs, total organic carbon (TOC), and percent moisture. Within the cap material, samples were extracted at 10 and 30 cm above the cap/dredged material boundary, and in Cores 97B-B and 97Q-A, an additional sample was extracted 2 cm above the interface. The cap samples were taken relatively close to the cap/dredged material boundary based on the assumption that if chemicals were migrating into the cap from below, there would be a gradient of decreasing concentration from this boundary to the outer surface of the cap (i.e., from "source" to "sink"). Detection of dioxin or furan in the cap above the boundary would indicate potential migration and necessitate further detailed sampling throughout the cap. Conversely, failure to detect dioxin or furan in the cap immediately above the boundary provides evidence that contaminants are not migrating to the outer surface of the cap. Within the dredged material, samples were extracted 10 cm below the interface.

Up to three additional samples were taken throughout the length of the fine-grained dredged material at the discretion of SAIC laboratory personnel. All of these samples were taken from material that appeared to be relatively homogenous. In order to obtain a sufficient quantity of sediment for testing PCDD/PCDFs and TOC, samples were taken from an approximate 4-cm thick plug encompassing the desired sample point. Sample locations within each core are noted in Section 4.

Sand cap material samples were removed from the core first to decrease the possibility of contamination. To further minimize contamination, only material not in contact with the core liner was used. Stainless steel spatulas and mixing bowls were used to remove and homogenize the sediment. Samples were placed into 125-ml precleaned glass jars supplied by the analytical laboratory. PCDD/PCDF samples were placed in amber containers due to the photosensitive nature of these compounds; TOC samples were placed in clear glass containers. Sampling equipment was rinsed with distilled water and then acetone between each sample. Samples were kept on ice (approximately 4° C) in coolers and in the dark, and were shipped by air freight to Pace Analytical Services, Inc. located in St. Paul, MN.

2.4 Geotechnical Analysis

2.4.1 Bulk Density and Water Content

Assuming no void space due to air, the wet mass of sediment divided by the volume yields the bulk density. Bulk density for the cores was determined by pushing a cylinder of known volume (39.06 cc) into the sediment surface of the core half, leveling off each end, and then weighing it. Voids or cracks in the sediment, which would affect bulk density measurements, were not noted for this suite of cores.

Water content is defined as the weight of water divided by the dry weight of the sample, and reported as a percentage. Mathematically, it is computed using the following formula:

$$\text{Water Content} = \frac{\text{wet weight - dry weight}}{\text{dry weight}} \times 100$$

It should be noted that in geotechnical analysis, this formulation may indicate water content values greater than 100%. For this analysis, the wet samples were weighed, dried at 110°C for 24 hours, and then reweighed according to the procedures outlined in ASTM Method D 2216. Because these samples were from the marine environment, when dried, the salt from the water is left behind, resulting in a higher dry weight (weight of solids) and consequently lower water content. Since geotechnical properties are generally based on sediments saturated with fresh water, the water contents obtained via the above formula were then normalized by an assumed salt content of 35 ppt, following ASTM procedures.

2.4.2 Grain Size

Grain size distributions of representative samples were determined in accordance with ASTM Method D 422. Sieve sizes for sand fraction analyses include US standard sieve sizes 10, 20, 40, 60, 100, and 200, to provide coarse (1-0 phi), medium (2-1 phi), fine (3-2 phi), and very fine (4-3 phi) sand fractions, respectively. Clay and silt fractions were measured using a hydrometer (ASTM Method D422). Size classifications are based on the Wentworth (1922) scale (Appendix E).

2.4.3 Atterberg Limits

Atterberg limits are index tests which give an indication of a soil's consistency. They are also used as a part of many soil classification systems, such as the Unified Soils Classification System (USCS). The limits, including liquid, plastic, and shrinkage, are indicators of the changes in consistency of fine-grained materials with changes in water content. The limits are based on the concept that a fine-grained soil can exist in a wide variety of conditions, ranging from liquid to plastic, semi-solid and solid, depending upon its water content. The greater the amount of water a soil contains, the less interaction there will be between adjacent particles, and the more the soil will behave like a liquid. Plastic limit (PL, the water content of soil at the boundary between the plastic and semi-solid states), liquid limit (LL, the water content at the boundary between semi-liquid and plastic states), and the plasticity index (PI, the range of water content over which the soil behaves plastically; mathematically, PI = LL-PL) were determined for representative samples of the fine-grained materials (ASTM Method D 4318), and corrected for an assumed 35 ppt salt content. Liquid limit can provide qualitative information on the strength of the sediment.

In the baseline, interim, and postdisposal coring surveys for the 1997 Category II Capping Project, Atterberg limits were analyzed using the dry preparation procedure outline in ASTM Method D 4318. For this project, however, measurement of the sediment behavior at its *in situ* water content is most relevant. By allowing these samples to dry before testing, the liquid and plastic limits may vary considerably from values that would have been obtained from undried samples (ASTM Method D 4318). Samples from the April 1998 first postcap survey were analyzed using both the wet and dry preparation methods and compared (SAIC 1998b). For the May 1999 one-year postcap suite of cores, all samples were prepared using the wet preparation procedure outlined in ASTM Method D 4318, and LL measured using the multipoint method.

2.4.4 Specific Gravity

Specific gravity is defined as the ratio of the mass of a unit volume of material to the same volume of gas-free distilled water at a stated temperature (ASTM Method D 854), and is represented by the following formula:

$$G_s = \frac{W_s}{V_s \gamma_w}$$

where:

W_s = weight of solids (i.e., dry weight)
V_s = volume of solids
γ_w = unit of weight of water = 1 g/cc

Specific gravity was measured within the dredged material layer of each of the cores, using ASTM D 854, Method A (procedure for oven dried test specimens).

2.4.5 Void Ratio

Void ratio is a parameter used to help assess the state of consolidation in sediment material. Using the raw data provided by GeoTesting Express, this value was calculated using the following formula:

$$\text{Void Ratio (e)} = \frac{V_v}{V_s}$$

where: V_v = volume of the voids
V_s = volume of the solids

The volume of the voids, V_v, refers to the amount of space occupied by water and air in a sample, and can be calculated as follows:

$$V_v = V_t - V_s$$

where: V_t = total volume of the sample
V_s = volume of the solids

Specific gravity, G_s, is also required as part of the calculations and defined as:

$$G_s = \frac{W_s}{V_s \gamma_w}$$

where: W_s = weight of solids (i.e., dry weight)
V_s = volume of solids
γ_w = unit of weight of water = 1 g/cc

Rearranging the above equation, the volume of solids, V_s, is calculated as follows:

$$V_s = \frac{W_s}{G_s \gamma_w}$$

2.5 Geochemical Analysis

2.5.1 Total Organic Carbon (TOC)

Total organic carbon (TOC) analyses were performed using EPA's SW-846 Method 9060 (USEPA 1997a). In this method, organic carbon is measured using a carbonaceous analyzer that converts the organic carbon in a sample to carbon dioxide (CO_2) by either catalytic combustion or wet chemical oxidation. The CO_2 formed is then either measured directly by an infrared detector or converted to methane (CH_4) and measured by a flame ionization detector. The amount of CO_2 or CH_4 in a sample is directly proportional to the concentration of carbonaceous material in the sample. Results in this report are expressed on a dry weight basis.

2.5.2 PCDD/PCDF Analyses

This section describes the methods used for sample preparation, extraction, and analysis of PCDDs/PCDFs, including QC samples. A detailed discussion was provided in the Quality Assurance Project Plan for Monitoring the Disposal of Dredged Material Containing Dioxin: Laboratory Analysis of Baseline/Post-Storm Samples (SAIC 1993). Results of QA/QC analyses are given in Chapter 3. Samples were analyzed by Pace Analytical, Inc. using EPA Method 8290 (USEPA 1997b), with modifications, such as the levels of the internal standards, recovery standards, and native spiking materials, at the levels described in EPA Method 1613 (USEPA 1994). Following extraction, sample extracts were analyzed for PCDDs/PCDFs using combined capillary column gas chromatography/high resolution mass spectrometry (HRGC/HRMS).

The 30 sediment samples were analyzed for the dioxin and furan compounds (PCDDs/PCDFs) listed below:

<u>Dioxins (PCDDs):</u>	<u>Furans (PCDFs):</u>
2,3,7,8-TCDD (Dioxin)	2,3,7,8-TCDF (Furan)
1,2,3,7,8-PeCDD	1,2,3,7,8-PeCDF
1,2,3,6,7,8-HxCDD	2,3,4,7,8-PeCDF
1,2,3,4,7,8-HxCDD	1,2,3,6,7,8-HxCDF
1,2,3,7,8,9-HxCDD	1,2,3,7,8,9-HxCDF
total 2,3,7,8-HpCDD	1,2,3,4,7,8-HxCDF
OCDD	2,3,4,6,7,8-HxCDF
	1,2,3,4,6,7,8-HpCDF
	1,2,3,4,7,8,9-HpCDF
	OCDF

The 17 PCDDs/PCDFs listed above are the compounds analyzed in Method 8290. Fourteen of these compounds are called "2,3,7,8-substituted PCDDs/PCDFs" and are the PCDDs/PCDFs believed to pose the greatest risks to human health and the environment based on structure activity relationships. The requested laboratory detection limit for both sample groups was 1 pptr for the tetra compounds, 5 pptr for the penta, hexa, and hepta compounds, and 10 pptr for the octa compounds.

Sediment Extraction. An aliquot of each sample was spiked with a ^{13}C-labeled internal standard solution and extracted for 18 hours using toluene in a Soxhlet extractor. The extracts were quantitatively transferred to Kuderna Danish concentrators, concentrated, and solvent exchanged to hexane. The hexane extracts were processed through the analyte enrichment procedures described below. One method blank and one laboratory spike sample was prepared with each group of up to 20 samples. Method blanks were used to identify any contamination that may be contributed by the laboratory during the preparation of samples for instrumental analysis. The laboratory quality control spike was prepared by extracting clean sand that had been fortified with unlabeled target PCDDs/PCDFs. Moisture content of the sediments was determined by oven drying separate aliquots of the samples until a constant dry weight was achieved.

Analyte Enrichment. In addition to the PCDDs/PCDFs, the extraction procedure often removes other compounds from the sample matrix. PCDDs/PCDFs are frequently associated with other chlorinated compounds such as polychlorinated biphenyls (PCBs) and polychlorinated diphenyl ethers (PCDPEs). PCBs can directly interfere with the analyses while other compounds can overload the capillary column, causing degradation in chromatographic resolution or sensitivity. Because this method measures very low levels of PCDDs/PCDFs, the elimination of interferences is essential. The analyte enrichment (clean up) steps described below were used to remove interferences from the extracts.

Immediately prior to clean up, extracts were spiked with a 2,3,7,8-TCDD-$^{37}Cl_4$ enrichment efficiency standard. The recovery of this standard can be used to differentiate between losses of analytes or internal standards during extraction and losses that occur during the various cleanup procedures. Each extract was diluted to 100 ml with hexane, transferred to a separatory funnel and washed with 1N sodium hydroxide, concentrated sulfuric acid, and aqueous sodium chloride (5% w/v) as needed. The hexane extract was then quantitatively transferred to a liquid chromatography column containing alternating layers of silica gel, 40% concentrated sulfuric acid on silica gel, and 33% 1N sodium hydroxide on silica gel. During this step, the acidic and basic compounds and easily oxidized materials were removed from the sample extract. The column was elutriated with 90 ml of hexane and the entire extract collected and concentrated, under ambient conditions, to a volume of 1 ml.

Each extract was then fractionated on a liquid chromatography column by elution using a series of organic solvents with toluene being the final eluant. The toluene fraction was collected, spiked with two recovery standards (1,2,3,4-TCDD-$^{13}C_{12}$ and 1,2,3,7,8,9-HxCDD-$^{13}C_{12}$) , and concentrated to a final volume of 20 µl. The 1,2,3,4-TCDD-$^{13}C_{12}$ is used to determine the percent recoveries of the tetra and penta chlorinated congeners, while the 1,2,3,7,8,9-HxCDD-$^{13}C_{12}$ recovery standard is used to determine the percent recoveries of the hexa, hepta, and octa chlorinated congeners.

PCDD/PCDF Analyses and Identification using HRGC/HRMS. Sample extracts were analyzed for the PCDDs/PCDFs using combined capillary column gas chromatography/high resolution mass spectrometry (HRGC/HRMS). Each 2,3,7,8-substituted PCDD/PCDF, with the exception of OCDF, was identified based on its retention time relative to the corresponding $^{13}C_{12}$-labeled isomer. A labeled OCDF standard was not used due to the associated interference with the determination of the native OCDD. The OCDF was identified by its retention time relative to $^{13}C_{12}$-labeled OCDD as determined from the daily calibration standard. The identification of all other PCDD/PCDF isomers was based on their retention times falling within their respective PCDD/PCDF retention time windows as established by a window defining mix of the isomers.

Relative response factors were calculated from analyses of standard mixtures containing representatives of each of the PCDD/PCDF congener classes at five concentration levels, and each of the internal standards at one concentration level. The PCDD/PCDF isomers were quantified by comparing the sum of the responses from the two ions monitored for each class to the sum of the responses from the two ion masses of the isotopically labeled internal standard. The quantitative results for the unlabeled results were corrected for the recovery of the internal standards, based on the assumption that losses of internal standards during sample preparation and analysis are proportional to the losses of the unlabeled PCDDs/PCDFs. The recovery of the internal standard was determined by comparing the response of the internal standard to the response of the appropriate recovery standard.

2.5.3 2,3,7,8-TCDD Toxic Equivalent Concentrations (TECs)

Method 8290 requires the calculation of the 2,3,7,8-TCDD Toxic Equivalent Concentration (TEC) to aid in the assessment of risks associated with exposure to these compounds. A 2,3,7,8-TCDD Toxicity Equivalence Factor (TEF; Safe 1990) is assigned to each of the 2,3,7,8-substituted PCDDs/PCDFs (Table 2-3). A TEF relates the toxicity of that congener to an equivalent concentration of the most toxic congener, 2,3,7,8-TCDD or dioxin. TEFs were defined by a 1989 international scheme (I-TEFs/89, NATO-CCMS 1988a, 1988b) and have been adopted by EPA (USEPA 1989). TEFs are different for each congener. The concentrations of congeners detected in environmental samples are multiplied by their respective TEF, and the products are summed over all congeners, yielding a concentration with the same toxicity as an equivalent amount of 2,3,7,8-TCDD. This concentration is variously referred to as a TCDD-Equivalent (TCDD-EQ), a TEQ (Toxic Equivalent), and, in this report, a Toxic Equivalent Concentration (TEC), expressed in units of ng/kg or pptr. The TECs were calculated using a value of one-half the LOD for values below detection (Clarke 1994; McFarland et al. 1994).

2.5.4 Normalization of PCDDs/PCDFs

Normalization is the process of relating the whole body or whole sediment concentration of a contaminant to a specific phase of the sediment. The normalized concentration then represents the concentration of the contaminant per unit of that phase of sediment. Normalization of contaminant concentrations is done when there is a significant body of evidence to suggest that the tissue or sediment phase that is used to normalize is the most important bulk phase that controls the behavior of a contaminant (Lake et al. 1990; O'Connor 1990). Normalization allows comparison of chemical concentrations when the controlling phase is variable in each sample. For organic compounds in tissues, the relevant controlling phase is usually the lipid content of the organism, as organic compounds segregate into lipids. For sediments, phases which are important for contaminants include fine-grained sediments (silts and clays) and organic matter, or TOC as measured here. In addition, the TOC concentration is an indicator of potential contaminant bioavailability. For neutral organic chemicals, TOC is the primary controlling phase; sorption to specific particle size fractions has been shown to be due largely to organic carbon content (Karickhoff et al. 1979). In sediments that have been influenced by anthropogenic activity, however, TOC is found to co-vary with contaminant concentrations because TOC itself is high around urban areas (NOAA 1991). Therefore, PCDDs/PCDFs are normalized both to TOC and the fine-grained sediment fraction for comparison. Dividing the measured reported sediment concentration of PCDDs/PCDFs normalizes sediment PCDDs/PCDFs by the fraction of TOC or by the fraction of fine-grained sediments present in the sediment sample. Normalization can be done using either wet weight or dry weight data; in this report sediment dry weight data were normalized. The data are presented as ng contaminant per kg TOC or fine-grained sediment.

2.6 Statistical Analysis

Descriptive statistics calculated for the geotechnical and chemical data included average, standard deviation, coefficient of variation, minimum, and maximum for each of the physical and chemical properties reported, grouped by unit (e.g., cap material and dredged material). For calculation of geochemical statistics, where concentrations were below detectable limits, one-half the Limit of Detection (LOD) was used (Clarke 1994).

The coefficient of variation (CV) is a measure of the amount of variability within a set of data. It is calculated using the following formula:

$$\text{Coefficient of Variation (CV)} = \frac{\text{standard deviation}}{\text{average}} \times 100$$

Table 2-3

2,3,7,8-TCDD Toxicity Equivalence Factors (TEFs) for Polychlorinated Dibenzodioxins and Dibenzofurans

Number	Compound(s)	TEF (pptr)
DIOXIN COMPOUNDS		
1	2,3,7,8-TCDD	1.0
2	1,2,3,7,8-PeCDD	0.5
3	1,2,3,6,7,8-HxCDD	0.1
4	1,2,3,7,8,9-HxCDD	0.1
5	1,2,3,4,7,8-HxCDD	0.1
6	1,2,3,4,6,7,8-HpCDD	0.01
7	OCDD	0.001
8	* Total – TCDD	0.0
9	* Total – PeCDD	0.0
10	* Total – HxCDD	0.0
11	* Total – HpCDD	0.0
FURAN COMPOUNDS		
12	2,3,7,8-TCDF	0.1
13	1,2,3,7,8-PeCDF	0.05
14	2,3,4,7,8-PeCDF	0.5
15	1,2,3,6,7,8-HxCDF	0.1
16	1,2,3,7,8,9-HxCDF	0.1
17	1,2,3,4,7,8-HxCDF	0.1
18	2,3,4,6,7,8-HxCDF	0.1
19	1,2,3,4,6,7,8-HpCDF	0.01
20	1,2,3,4,7,8,9-HpCDF	0.01
21	OCDF	0.001
22	* Total – TCDF	0.0
23	* Total – PeCDF	0.0
24	* Total – HxCDF	0.0
25	* Total – HpCDF	0.0

* Excluding the 2,3,7,8-substituted congeners.
Reference: USEPA 1989

3.0 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

3.1 Geotechnical QC Data

All analyses were completed in accordance with the project objectives, and data were fully documented. Geotechnical data were received from GeoTesting Express in both hard copy and electronic formats.

All geotechnical analyses were conducted using standard ASTM methods. As part of these methods, associated QA/QC procedures were followed. Other QC procedures in the analysis of geotechnical data include triplicate analysis of water content and grain size. These tests were preformed in the sand cap material of Core 97B-B, and within the dredged material sediments of Core 97C-B.

The coefficient of variation (CV) was used to evaluate the precision of these data. Water content triplicates had a CV of 0.5% and 0.3% for the sand cap and dredged material layers, respectively (Table 3-1). For the major grain size components, defined as being ≥20%, CVs ranged from 0 to 2.9%. When the CV is calculated for small numbers, particularly with a large range, the values tend to be skewed towards the high end. For this reason, the CV was calculated only for grain sizes comprising ≥20% of the sample. Overall, the CVs for these triplicate analyses indicate very good precision.

3.2 Chemical QC Data

Data quality is typically assessed in relation to specified criteria for precision, accuracy, representativeness, comparability, and completeness (PARCC). Analytical precision is expressed as the percent difference between results of replicate samples (Relative Percent Difference [RPD] or Coefficient of Variation [CV]). Analytical accuracy of the laboratory is evaluated quantitatively as the percent recovery of a spiked standard compound added at a known concentration to the sample before analysis. When spiked duplicates are run, the results can be expressed as an RPD to evaluate precision of the analysis of the spiked compounds. By inference, the precision of analysis of other related compounds should be similar. Laboratory accuracy also is evaluated qualitatively by evaluating the laboratory QC information on sample holding times, method blank results, tuning and mass calibration, recovery of internal standards, laboratory quality control samples, and initial and continuing calibration checks. The following section defines the various QA/QC requirements and summarizes the data quality objectives for this project.

3.2.1 Sample Tracking Procedures

SAIC Standard Operating Procedures for sample tracking and custody were followed. In preparation for the field survey, a checklist of all samples to be collected was prepared. Sample containers were chemically cleaned I-Chem® jars, and the labels were completed in indelible ink. After samples were placed inside, the jars were sealed with waterproof tape. Label information included the date, sample location, station number, replicate number, and type of analysis. All

Table 3-1

Geotechnical Triplicate Analysis Values for QA/QC

	Water Content* (%)	Percent				Sand Components			
		>Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Coarse (%)	Medium (%)	Fine (%)	Very Fine (%)
Sand Cap	19.5	2.5	96.5	1.0		17.5	48.0	28.0	3.0
Material	19.6	2.5	96.5	1.0		17.5	49.0	27.0	3.0
(Core 97B-B)	19.4	2.5	96.5	1.0		17.5	48.0	28.0	3.0
S.D.	0.1	**	0.0	**		**	0.6	0.6	**
AVG.	19.5	**	96.5	**		**	48.3	27.7	**
CV (%)	0.5	**	0.0	**		**	1.2	2.1	**
Dredged	43.9	1.5	37.0	40.5	21.0	3.5	10.0	10.5	13.0
Material	43.6	2.0	36.5	40.5	21.0	3.0	10.0	10.5	13.0
(Core 97C-B)	43.7	2.0	37.5	38.5	22.0	3.0	10.0	10.5	14.0
S.D.	0.2	**	0.5	1.2	0.6	**	**	**	**
AVG.	43.7	**	37.0	39.8	21.3	**	**	**	**
CV (%)	0.3	**	1.4	2.9	2.7	**	**	**	**

S.D = Standard Deviation

CV = Coefficient of Variation (see Section 2.6)

A legend for grain sizes can be found in Appendix C

*Corrected for 35ppt salinity

**CVs were only calculated for major grain size components (>20%)

sediment chemistry samples were stored at 0-4° C. Chain-of-custody records were maintained for all samples.

3.2.2 Sample Holding Times

The sediment samples were collected on May 18, 1999. They were stored under refrigeration and in the dark until they could be shipped to the laboratory on May 19, 1999. The laboratory received the samples on May 20, 1999. Extraction of sediment samples was undertaken from June 15 to 16, 1999, and the samples were analyzed from June 23 to July 23, 1999.

The recommended maximum holding time for dioxin/furan samples is 30 days from sample collection to extraction, and 45 days from collection to analysis, as specified in Method 8290 (USEPA 1997b). The more recent Method 1613 states, however, that there are no demonstrated maximum holding times associated with PCDDs/PCDFs in aqueous, solid, semi-solid, tissues, or other sample matrixes, as well as extracts, and samples may be stored up to one year (USEPA 1994). Samples were held for a maximum of 29 days between collection and extraction and 66 days between collection and analysis. These samples were stored for less than the one-year recommendation of Method 1613 and the data, therefore, are considered valid with respect to sample holding time requirements.

3.2.3 Method Blanks

Data from three method blanks were submitted for the 30 analyzed samples, meeting the requirement of one blank for every 10 samples of sediment. The method blanks were free of PCDDs and PCDFs, with the exceptions of trace background levels (0.20 ng/kg, or pptr) of 1,2,3,7,8-PeCDF, 1,2,3,4,7,8-HxCDF (0.29 pptr), 2,3,4,6,7,8-HxCDF (0.16 and 0.34 pptr), 1,2,3,4,6,7,8-HpCDF (0.18 pptr), and slightly higher levels (0.27 and 0.81 pptr) of OCDF and (0.99 and 2.30 pptr) OCDD. These measured background levels were all below the instrument calibration ranges. In the data report supplied by the laboratory, samples containing the above listed compounds within five times the associated blank level were flagged. Sample values that are less than five times the associated method blank cannot be distinguished from background. These flags occurred 22 times within 16 samples (Appendix D).

3.2.4 Assessment of Analytical Accuracy

Analytical accuracy is evaluated by examining the percent recovery of a known concentration of a compound spiked to the environmental sample before analysis. The closer that the numerical value of the measurement approaches the actual concentration of the compound, the more accurate the measurement. The percent recovery values are calculated using the following equation:

$$\frac{A_r - A_o}{A_f} \times 100$$

where: A_r = Total compound concentration detected in the spiked sample
A_o = Concentration of the compound detected in the unspiked sample
A_f = Concentration of the spike added to the sample

Internal standards consisting of native standard materials were added as spikes to each sample prior to extraction in order to determine the percent recovery of spike, and to evaluate overall accuracy of the analysis for each individual spike. Recoveries of isotopically-labeled PCDD/PCDF internal standards used as spikes must fall within the range of 40 to 135% as stated in EPA Method 8290 (USEPA 1997b). Measured recoveries of spiked internal standards for this data set generally ranged from 40 to 106%, indicating a level of efficiency in the extraction and enrichment steps that is considered typical for this matrix.

In addition to internal isotopically-labeled standards, matrix spike (MS) and matrix spike duplicate (MSD) samples were prepared from three of the submitted samples: 97B-B (130 cm), 97E-A (138 cm), and 97U-A (121 cm). Matrix spike (MS) and matrix spike duplicates (MSD) are prepared by dividing a sample into multiple aliquots and spiking an aliquot with a known concentration of analyte and finally proceeding with the analysis as though the spike was a sample. The laboratory standard operating procedure targets a range of 75 to 125% recovery. The MS/MSD recoveries indicated acceptable accuracy; recovery rates ranged from 73 to 114%. Although the recovery rates were slightly out of range they were deemed acceptable.

A laboratory QC spike sample was also prepared with each sample batch by extracting clean sand that had been fortified with native standards. Recoveries of spiked native compounds must fall within the range of 70 to 130% as defined by the laboratory standard operating procedure. The recoveries of the analytes from the spiked samples ranged from 74 to 96%, indicating acceptable accuracy.

3.2.5 Assessment of Analytical Precision

Analytical precision is expressed as the relative percent difference (RPD) between two results or the coefficient of variation (CV) between three or more results. Three types of replicate samples were examined for precision analysis: matrix spike duplicates (MS/MSD), laboratory spike samples, and three samples that were homogenized by the laboratory and then divided into triplicate subsamples. The triplicates were analyzed independently. The closer the numerical values of the measurements are to each other, the lower the RPD or CV. Low RPD or CV values indicate a high degree of analytical precision.

The relative percent difference (RPD) between two sample results was calculated using the following equation:

$$\text{RPD} = \frac{(\text{sample result} - \text{duplicate result})}{(\text{sample result} + \text{duplicate result}) \ / \ 2} \times 100$$

The RPD for the matrix spike duplicates should be 20% or less for a high degree of precision. The CV values for the laboratory triplicates should equal to 25% or less (USEPA 1997b).

The RPD values obtained for the recovery of the spiked compounds in the MS/MSD samples ranged from 0.0 to 10.5%, indicating a high degree of precision. The CV for the laboratory spike samples ranged from 7.6 to 23.6%, indicating acceptable precision. Three samples (97B-B [110 cm], 97Q-A [142 cm], and 97R-B [162 cm]) were each split into three aliquots to be analyzed as triplicates. Precision calculations could not be made for 97B-B (110 cm) as dioxin or furan was not detected in any of these samples. The CVs for 97Q-A (142 cm) and 97R-B (162 cm) were 44.6% and 12.0%, respectively, indicating an acceptable degree of precision. While the 44.6% CV appears high, when comparing the values of small numbers their differences are magnified. Additionally, two of the three replicate values from this sample were below the required LOD of 1.0 pptr.

3.2.6 2,3,7,8-TCDF Confirmation

Confirmation of 2,3,7,8-TCDF was performed on all samples having detected concentrations of this isomer. On the initial DB-5 capillary gas chromatographic column, other isomers can coelute with furan. Historically, problems have been associated with the separation of 2,3,7,8-TCDF and 2,3,4,7-TCDF. Therefore, these samples were re-run on a second, DB-DIOXIN column in order to confirm the presence of the 2,3,7,8-TCDF isomer. In this instance, samples from cores 97B-B (138 cm), 97C-A (104 cm), 97E-A (178 cm), 97Q-A (142 [replicates 1 and 3] and 162 cm), 97R-B (102 and 162 [replicates 2 and 3] cm), and 97U-A (141 cm) also had interferences using the DB-DIOXIN column. Therefore, for these samples, 2,3,7,8-TCDF values have been flagged as having possible contributions from other TCDF isomers.

Interferences from polychlorinated diphenylethers (PCDPEs) were found in many of the samples. PCDPEs can give false positive responses for PCDFs. Therefore, any PCDF response exhibiting a simultaneous response in the PCDPE channel was omitted from the calculations; as a result, the limits of detection (LODs) for affected isomers were elevated. The degree of elevation of LODs tends to increase as the degree of chlorination of the compound increases.

3.2.7 Instrument Performance

Continuing calibration checks of the instrument must show a response deviation within ± 25% RPD for the 17 PCDD/PCDF compounds of interest and within ± 35% RPD for the nine isotopically-labeled PCDD/PCDF internal standards (USEPA 1997b). Daily instrument calibration checks showed response factor deviations within these specified limits.

3.2.8 Total Organic Carbon

A total of 30 sediment core samples were analyzed for total organic carbon (TOC) according to EPA Method SW846 9060. Analyses were carried out between May 28 and June 7, 1999. Triplicates were taken from three sediment core samples, 97B-B (170 cm), 97C-A (184 cm), and 97R-B (62 cm) which yielded CVs of 18.6%, 7.8% and 15.0%, respectively. Analyses of TOC are typically subject to a high degree of variation. This high variation combined with the low TOC values found in the cap material caused the higher CV value of 20.4%. These CV values generally indicate acceptable precision. There were two laboratory control samples analyzed with recoveries between 73% and 113%, These are close enough to the target range of 75–125% to be considered indicative of acceptable accuracy.

3.2.9 Representativeness, Completeness, and Comparability

Sample representativeness was ensured during the sampling survey by collecting a sufficient number of sediment samples from the cap (14 samples) and dredged material (16 samples) portions of the cores. All samples were collected in a uniform manner and are considered to be representative (see Methods).

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. Comparability is based in large part on the other PARCC parameters because precision and accuracy must be known to compare one data set with another. To optimize comparability, sampling stations and sampling procedures used in the May 1999 survey were consistent with those employed in previous surveys of the New York Mud Dump Site in which chemistry samples were collected (1993 Dioxin Capping Monitoring Project baseline and postcap surveys). Analytical methods and protocols were also the same for this and past surveys, and the same laboratory (Pace Analytical, Inc., formerly known as Maxim Technologies, Inc.) performed the analyses for all surveys.

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4.0 RESULTS

4.1 Core Descriptions and Photography

This section presents descriptions of the cores based on visual observations and photographs. Core photographs with detailed descriptions are provided in Appendix A.

The material observed in this suite of cores was classified as either sand cap material (C) or project dredged material (DM). The specific characteristics of each of these material units are discussed in detail below. Visual observations made by SAIC and GeoTesting Express, discrete core data collected by GeoTesting (Appendix B), down-core geotechnical profiles of water content and bulk density (Appendix C), and postcap bathymetric results (SAIC 1999) all were consulted in order to arrive at the material type classifications presented.

In previous surveys, material was recovered that clearly represented sediment that predated the 1997 project (PP), comprised of muddy sand. This material was identified as being either basement sediments from before the 1997 Category II Capping Project material was placed in the area, or as sand cap material from the 1993 Dioxin Mound Capping Project. In this survey, there was no clear evidence of either of these types of material being recovered, and therefore, all material below the sand cap layer was classified as being project dredged material (DM).

4.1.1 Sand Cap (Cap)

The sand cap material was a mix of fine to coarse sand that ranged from dark gray to grayish brown and brownish gray in color. Shell fragments were observed within the sand cap layer of all the cores. The transition between the cap and dredged material units was clearly evident, as seen in the core photographs (Appendix A) and the geotechnical profiles (Appendix C). Sand from the cap was often observed along the outer edge of the dredged material in the core liner for the first few centimeters. This was due to drag-down during the coring process (e.g., Appendix A, Cores 97D-B and 97P-A).

All 14 cores were collected within the cap boundary footprint (Figure 4-1). With the exception of Core 97R-B, all cores contained a sand cap layer greater than one meter (range from 106 to 229 cm; Table 4-1). The overall average sand cap thickness for all of the 14 cores was 153 cm (Table 4-1). A cap thickness of 92 cm was measured for Core 97R-B. Coring surveys from the previous 1993 Dioxin Capping Monitoring Project, as well as from the first postcap coring survey of the 1997 Category II Capping Project, have shown similar spatial variability in cap thickness, both among replicate cores and at similar locations through time (SAIC 1995a, 1995b, 1998b). The sand cap thicknesses measured in the cores of the present survey are consistent with results collected during the postcap and one-year postcap bathymetric surveys (SAIC 1998e, 1999), as well as the postcap subbottom (SAIC 1998f) survey.

4.1.2 Project Dredged Material (DM)

Overall, the DM unit was composed of fine-grained black, brown, or dark gray silty clay material. The material was very “sticky” and appeared to be more cohesive than in the previous

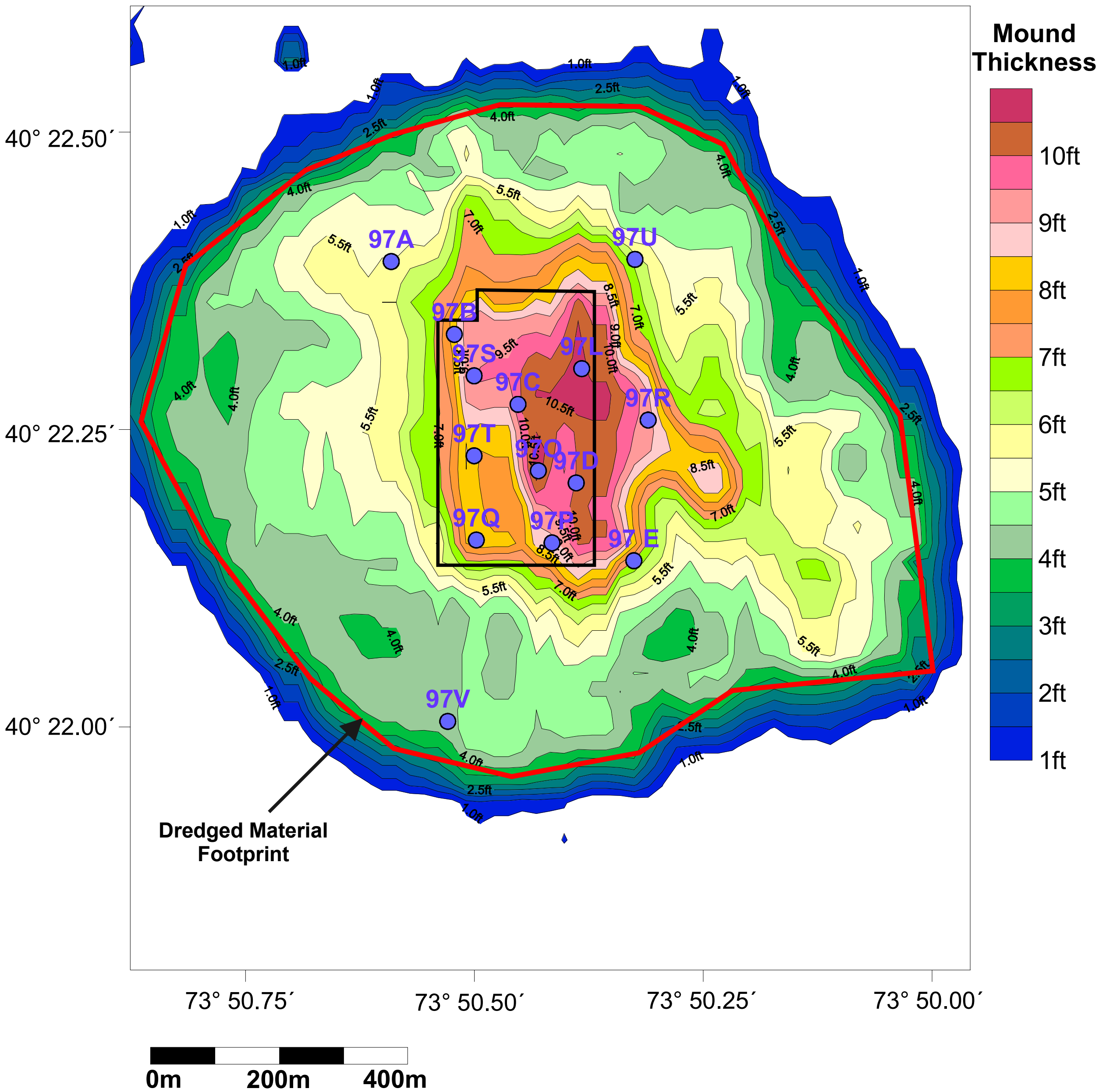


Figure 4-1. One-year postcap core locations superimposed on bathymetric results showing the total capped mound thickness. Bathymetric results are based on the depth difference between the baseline (April 1997) and one-year postcap (April 1999) bathymetric surveys.

Table 4-1

Thickness of Sand Cap as Measured in the Collected Sediment Cores

Core	Cap Thickness (cm)
97A-B	106
97B-B	140
97C-B	134
97D-B	126
97E-A	168
97L-B	221
97O-A	148
97P-A	190
97Q-A	132
97R-B	92
97S-B	158
97T-A	150
97U-A	151
97V-B	229
Average	153

project surveys. As material consolidates and becomes more compact, interstitial water is displaced, resulting in a more solid and cohesive state. This observation, therefore, was an indication that increased consolidation had occurred between the previous and present surveys.

Large pieces of shell, generally oyster and blue mussel, were present in the DM unit in a majority of the collected cores (e.g., 97A-B and 97D-B). In Core 97P-A at ~162 cm, and in Core 97S-B from 260 to 274 cm, bands of red clay were noted. In Cores 97A-B, 97B-B, 97C-B, 97P-A, 97R-B, and 97T-A, bands and pockets of fine gray sand were observed at various depths. Core 97U-A, from 210 to 245 cm, contained a layer of very wet black silty clay with a lot of wood material and shell. These observed variations in color and texture are typical of the project-dredged material, as noted in previous surveys (SAIC 1998b, 1998h), and are attributed to its natural variability.

4.2 Geotechnical Analyses

Geotechnical data for the discrete samples taken within each core are presented in Appendix B. Summary statistics for the cap and DM material units are presented in Tables 4-2a and 4-2b and discussed in the following sections.

Table 4-2a

Summary of Physical Properties for Sand Cap Material

	Sand Cap Material (C)					
	Average	Std. Dev.	Coefficient of Variation (%)	Min	Max	Sample Count
Water Content (%)	20.1	2.3	11.3	15.5	31.2	72
Bulk Density (g/cc)	1.84	0.05	2.99	1.67	1.95	70
> Coarse Sand (%)	3.2	2.0	62.2	0.5	9.5	30
Total Sand (%)	95.8	2.0	2.0	90.0	98.5	30
Coarse Sand (%)	15.3	6.7	43.9	4.0	30.5	30
Medium Sand (%)	45.0	7.6	17.0	32.0	61.0	30
Fine Sand (%)	31.3	10.3	33.0	10.0	51.0	30
Very Fine Sand (%)	4.3	2.3	54.6	1.0	9.0	30
Silt & Clay (%)	1.0	0.2	20.4	0.5	2.0	30
Liquid Limit (%)	---	---	---	---	---	---
Plasticity Index (%)	---	---	---	---	---	---
Specific Gravity	---	---	---	---	---	---
Void Ratio	0.7	0.1	7.3	0.6	0.8	70
USCS Symbol(s)*	SP					30

Table 4-2b

Summary of Physical Properties for Project Dredged Material

	Dredged Material (DM)					
	Average	Std. Dev.	Coefficient of Variation (%)	Min	Max	Sample Count
Water Content (%)	62.5	14.3	22.8	19.7	113.6	183
Bulk Density (g/cc)	1.62	0.09	5.64	1.36	1.97	181
> Coarse Sand (%)	1.8	3.7	204.2	0.0	23.5	67
Total Sand (%)	23.9	9.7	40.8	10.0	59.5	67
Coarse Sand (%)	1.6	1.5	92.4	0.5	11.5	67
Medium Sand (%)	5.6	3.4	59.8	0.5	19.5	67
Fine Sand (%)	6.2	3.9	62.9	1.5	20.0	67
Very Fine Sand (%)	10.4	3.5	33.1	3.0	20.5	67
Silt (%)	49.0	7.9	16.1	18.0	68.5	67
Clay (%)	25.3	5.3	21.0	9.0	39.0	67
Liquid Limit (%)	63.4	11.5	18.2	38.1	95.5	39
Plasticity Index (%)	35.6	8.7	24.5	16.2	62.7	39
Specific Gravity	2.60	0.03	1.01	2.55	2.66	39
Void Ratio	1.64	0.37	22.77	0.58	3.09	181
USCS Symbol(s)*	CH(33), CL(4), SC(2)					39

4.2.1 Water Content

The water content of the cap material was relatively uniform throughout all of the cores, ranging from 15.5 to 31.2%. The average water content was 20.1% ± a standard deviation of 2.3%. This uniformity reflects the consistency of sediments in the source area (Ambrose Channel).

Water content in the DM unit ranged from 19.7 to 113.6%, and had an average of 62.5 ± 14.3% (CV = 22.8%; Table 4-2b). In general, a linear relationship is expected between water content and bulk density in the DM. When the water content values for these data were plotted against bulk density (Figure 4-2), the majority of values for the DM unit fell within a water content range of 40 to 80%. Two DM sample values (Core 97C-B, 205-210 cm; Core 97P-A, 262-268 cm [Appendix B]) fell within the vicinity of the cap material values, and represent dredged material samples taken within pockets of fine sand noted in Section 4.2.1. Due to its mineral structure, sand is a poor retainer of water, and therefore tends to have lower water content values compared to silt and clay.

Two cap samples had slightly higher water content values (Core 97L-B, 180-221 cm, 29.3%; Core 97S-B, 105-130 cm, 31.2% [Appendix B]). These cap samples contained slightly higher percentages of finer grained material, and, therefore, a greater ability to retain water, increasing the water content. Small patches of fine-grained sediment are known to occur within the sand cap as a result of entrainment during the dredging process and lateral transport of silt-clay from surrounding areas following sand cap placement.

The average water content value for the DM unit observed in this survey (62.5 ± 14.3%) was slightly higher than that observed in the April 1998 postcap coring survey (59.7 ± 13%; SAIC 1998b). A two-tailed t-test for samples with unequal variances, however, indicated that the observed difference was not statistically significant. These data suggest that minimal quantifiable consolidation had occurred during the past year. Further discussion of the geotechnical trends is provided in Section 5.

4.2.2 Bulk Density

In general, bulk density is inversely proportional to water content. During the process of consolidation, interstitial water is forced from pore spaces, and that volume is then replaced by sediment (solids). This results in more sediment being present within an equal sample volume, thereby increasing the material's bulk density. Within the cap material, the average bulk density was 1.84 ± 0.05 g/cc, with a range of 1.67 to 1.95 g/cc. Within the DM unit, the average bulk density value was 1.62 ± 0.09 g/cc, and ranged from 1.36 to 1.97 g/cc.

The average bulk density of the dredged material has changed only slightly from 1.60 to 1.67 to 1.62 between the postdisposal (August 1997; SAIC 1998g), postcap (April 1998; SAIC 1998b), and one-year postcap (May 1999) surveys. A further discussion of these geotechnical trends is discussed in Section 5.

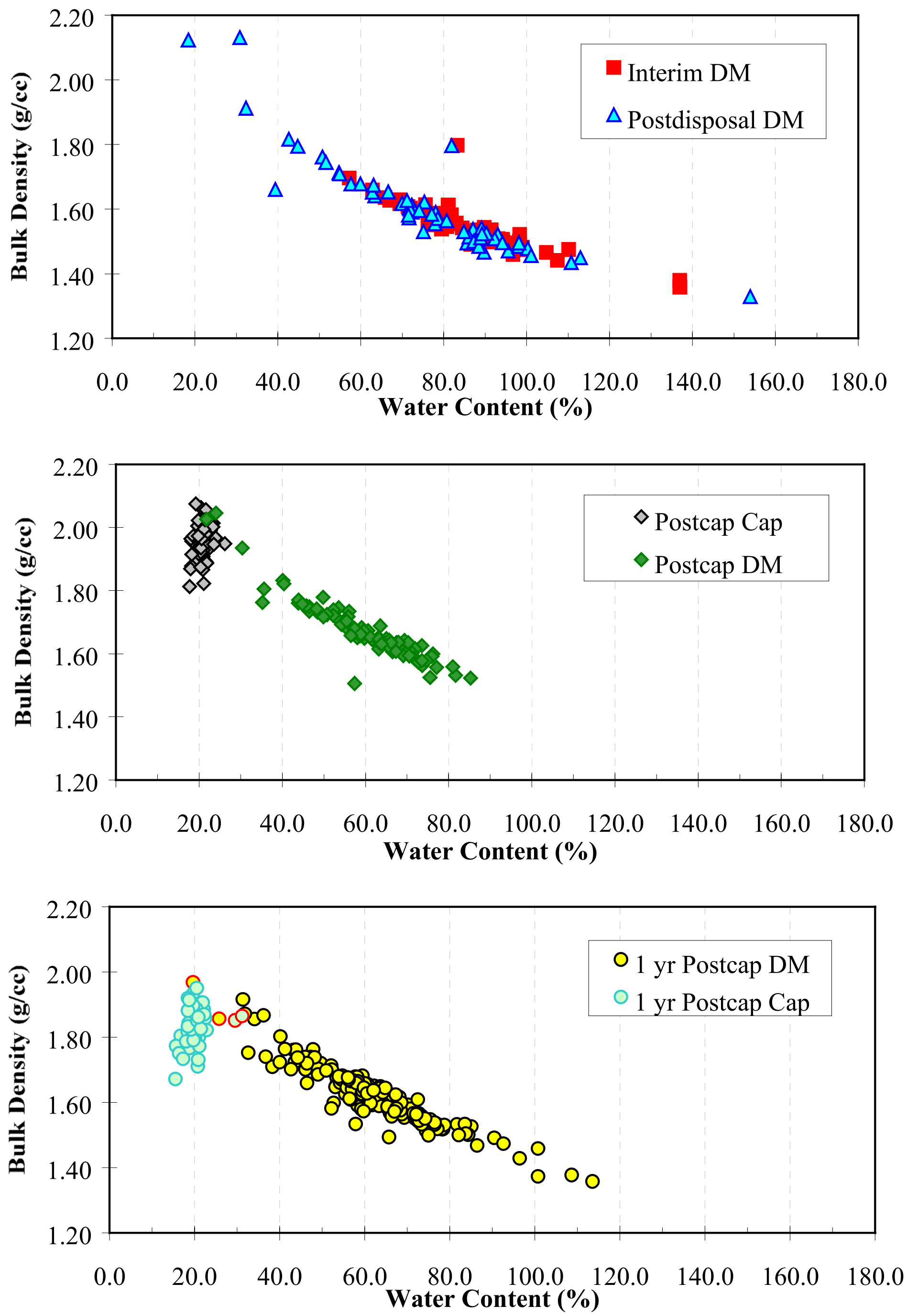


Figure 4-2. Plot of water content versus bulk density for datasets collected during the interim disposal, postdisposal, postcap, and one-year postcap sediment coring surveys. Points outlined in red indicate outliers discussed in Section 4.2.1.

4.2.3 Grain Size

Grain size measurements indicated a sharp distinction between the sand cap and underlying finer grained DM (Appendix B). Within the cap material, medium sand was the most dominant component (average of 45.0%) and showed the least variation among cores (CV = 17.0%; Table 4-2a). Coarse sand (average of 15.3%) and fine sand (average of 31.3%) fractions also were significant components. Very little silt and clay (average of 1.0%) was present within the cap material. These results are very similar to those obtained in the previous post-cap survey of April 1998. In that survey, it was found that the sand cap also was comprised predominantly of medium sand (44%), with lesser amounts of coarse sand (20%) and fine sand (28%) fractions.

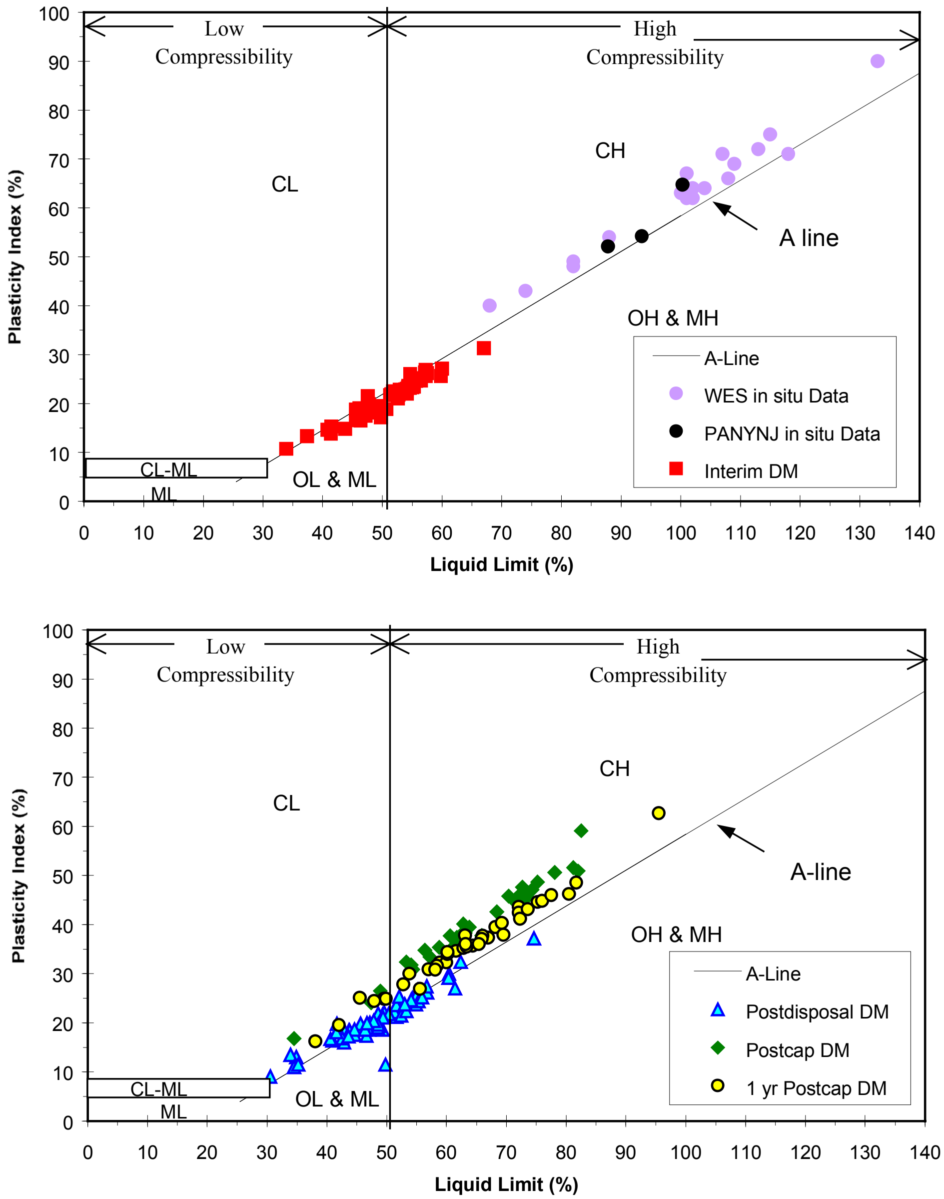
Silt was the dominant grain size within the DM unit (average of 49.0 ± 7.9%; Table 4-2b), followed by clay-sized particles, averaging 25.3 ± 5.3%. This is generally consistent with observed values for the interim (51.8% silt, 30.5% clay; SAIC 1998h), postdisposal (52.4% silt, 27.4% clay; SAIC 1998g), and first postcap (62.4% silt, 19.4% clay; SAIC 1998b) coring datasets. Within all four datasets, sand was observed only as a patchy and variable component within the DM unit.

4.2.4 Atterberg Limits

Atterberg limits were only measured within the fine-grained sediment fractions (i.e., silt and clay). Within the fine-grained DM unit, average values for liquid limit and plasticity index were 63.4 ± 11.5% and 35.6 ± 8.7% (Table 4-2b), respectively. The Atterberg limits were not distinct enough to differentiate changes within the dredged material texture. In general, water content values were observed to be lower than measured liquid limits (Appendix B), indicating increased material stability as consolidation has occurred.

In December 1996, WES took core samples of the pre-dredged material in both Port Newark and Port Elizabeth. This data was used to model and help design the 1997 Category II Project (Rollings and Rollings 1998a). Within the same time frame, the Port Authority of New York and New Jersey (PANYNJ) collected samples within Port Elizabeth as part of a study to look at maintenance dredged material properties in the area (PANYNJ 1996). These *in situ* values were plotted on a plasticity chart along with Atterberg limits measured for the interim disposal, postdisposal, postcap, and one-year postcap datasets (Figure 4-3). Plasticity charts are used to help classify silt and clay into the various subdivisions described by the USCS criteria (Section 4.2.5). The “A-line” (Figure 4-3) indicates the boundary between inorganic clay (symbols CH and CL, above the line) and the inorganic silt and organic clay (symbols ML, MH, OL, and OH) sediments. In such a chart, any data points that fall within the shaded box have characteristics of both inorganic silt and clay, and therefore carry a double classification. Also, sediments with a liquid limit of greater than 50% are generally considered to be highly compressible. Further details of this classification system can be found in standard soil classification texts (e.g., Wu 1976).

When plotted, the one-year postcap data generally fell above the A-line, indicating a mixture of inorganic clay and silt. The observed variability is attributed to the natural heterogeneity of the dredged material. Preliminary analysis of the first postcap cores analyzed by WES have shown



ML	inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
CL	inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
OL	organic silts and organic silt-clays of low plasticity
MH	inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
CH	inorganic clays of high plasticity, organic silts
OH	organic clays of medium to high plasticity

Figure 4-3. Plasticity chart for DM from the interim disposal (July 1997), postdisposal (August 1997), postcap (April 1998), and one-year postcap (May 1999) datasets. *In situ* data collected by WES and PANY/NJ for Port Newark and Port Elizabeth (December 1996) are also included.

that considerable variability in material type and density was apparent throughout the sampling site and even within duplicate cores (Rollings and Rollings 1998a). It is also important to note that the dredged material deposited as a part of this project came from several different sites, and that geological variation within and between these sites is inherent. By nature, dredged materials are highly patchy and heterogeneous (Rollings and Rollings 1998a). Some of the *in situ* measurements were made in material not ultimately dredged in this project, providing another explanation for the marked difference among the values seen in Figure 4-3.

The first postcap and one-year postcap data also show a shift with respect to the interim disposal and postdisposal datasets. This shift can be explained by the change in testing procedures used to measure the Atterberg limits. In previous surveys, a dry sample preparation was used. However, the protocol was changed to use the wet sample preparation techniques presented in ASTM D 4318. A detailed discussion of this change can be found in the first postcap coring report from April 1998 (SAIC 1998b).

4.2.5 USCS Classification

The Unified Soil Classification System (USCS) is used to help provide consistent soil type descriptions using visual observations and geotechnical characteristics. The system was developed in 1948 for primary use in airfield construction, and later modified in 1952 for use in other types of construction (Bowles 1979). The classification system is useful to categorize the saturated marine sediments from this project.

Classification of the cap material was uniformly SP (poorly sorted sand). The majority of samples (33 of 39) from the DM unit were classified as CH (inorganic clays of high plasticity, organic silts). Four of 39 samples were classified as CL (inorganic clays of low to medium plasticity, sandy clays, and silty clays) and the remaining two samples were classified as SC (clayey sands, poorly graded sand-clay mixtures).

4.2.6 Specific Gravity

Specific gravity values for DM ranged from 2.55 to 2.66, and had an average of 2.60 ± 0.03 (Table 4-2b). These values coincide well with the range (2.52 to 2.73) and average (2.64 ± 0.05) values measured in the April 1998 postcap survey (SAIC 1998b). These measured values also are consistent with the literature-derived value of 2.7 assumed in the previous interim disposal and postdisposal coring reports. No specific gravity measurements were made within the cap material, so an assumed value of 2.67 was derived from the literature for sand (Das 1983).

4.2.7 Void Ratio

Void ratio is a calculated value (Section 2.4.6) used to help assess a material's state of consolidation. As sediments consolidate, void ratio values are expected to decrease over time. In the case of sand, because it is considered relatively incompressible, these changes should be negligible. Void ratio values calculated for the sand cap material in this survey ranged from 0.6 to 0.8, and had an average of 0.07 ± 0.05 (Table 4-2a). These values are essentially the same as those observed in the April 1998 postcap survey, where void ratios ranged from 0.5 to 0.8, with an average of 0.7 ± 0.1 (SAIC 1998b).

Void ratio values for the DM unit ranged from 0.58 to 3.09, and had an average of 1.64 ± 0.37 (Table 4-2b). Statistically, a two-tailed t-test assuming equal variances showed no difference between these values and those from the April 1998 survey (range 0.59 to 2.21, average 1.56 ± 0.31; SAIC 1998b). A further discussion of these geotechnical trends is provided in Section 5.

4.3 Chemical Analysis

The following sections present the chemical results for the May 1999 one-year postcap coring survey. Samples for TOC, dioxin, and furan analyses were collected from both the sand cap and underlying black clayey-silt dredged material (DM) found in the cores.

4.3.1 Total Organic Carbon

Total organic carbon (TOC) concentrations in the core samples ranged from 0.027 to 1.693% (Table 4-3). The cap material had the lowest TOC concentrations, ranging from 0.027 to 0.204%, with an overall average value of 0.070% ± 0.046. The DM had TOC values ranging from 0.404 to 1.693%, with an overall average value of 1.314% ± 0.329.

An overall average TOC value for all four postcap surveys for the 1993 Dioxin Project was calculated and compared to the results from the April 1998 and May 1999 postcap surveys (Figure 4-4). The average TOC concentration in the cap material was comparable for the 1993 Dioxin Project and the 1997 Capping Project. The DM consistently had a higher average and range of TOC concentration than the cap material for both the 1993 Dioxin Project and 1997 Capping Project. The dredged material from the May 1999 one-year postcap survey showed a lower average concentration than both the 1993 Dioxin Project and the April 1998 postcap survey.

4.3.2 Unnormalized Concentrations of Dioxin and Furan

Unnormalized sediment concentrations of all measured PCDDs/PCDFs, including congener data, are presented on a dry weight basis for the six cores in Appendix D. All 14 samples of the cap material had dioxin values below the Level of Detection (LOD), but 3 of the 14 samples had detectable levels of furan. However, none of the cap material samples had furan detected at greater than the 1.0 pptr minimum LOD.

A total of 16 samples were taken from the underlying DM and analyzed for PCDDs/PCDFs. Twelve samples had detectable levels of dioxin and nine samples had detectable levels of furan. Values for dioxin ranged from 0.15 to 7.0 pptr and furan values ranged from 0.075 to 4.1 pptr.

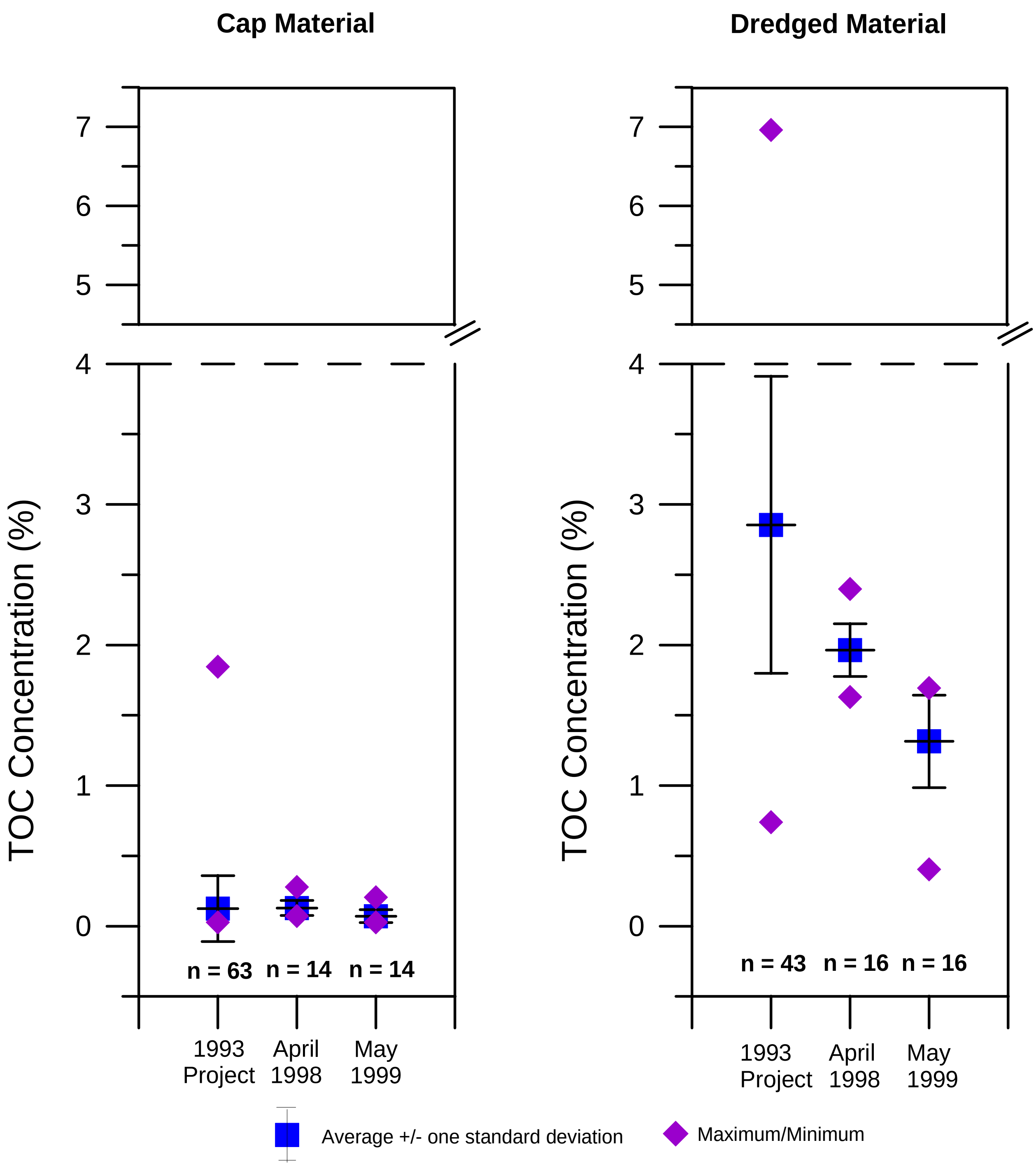


Figure 4-4. Comparison of average total organic carbon concentration in cap material (left graph) and dredged material (right graph) between the April 1998 and May 1999 postcap coring surveys of the 1997 Category II Capping Project and the 1993 Dioxin Capping Monitoring Project.

Table 4-3

Total Organic Carbon Results from One-Year Postcap Core Samples

Core	Core Depth* (cm)	Relative Sample Location** (cm)	TOC (%, dry wt.)	Material Type
97B-B	110	(+) 30	0.078	sand
	130	(+) 10	0.027	sand
	138	(+) 2	0.041	sand
	150	(-) 10	0.404	dredged material
	170	(-) 30	1.693§	dredged material
97C-A	104	(+) 30	0.051	sand
	124	(+) 10	0.053	sand
	144	(-) 10	0.774	dredged material
	164	(-) 30	1.160	dredged material
	184	(-) 50	1.337§	dredged material
97E-B	138	(+) 30	0.055	sand
	158	(+) 10	0.061	sand
	178	(-) 10	1.310	dredged material
	198	(-) 30	1.590	dredged material
97Q-A	102	(+) 30	0.120	sand
	122	(+) 10	0.044	sand
	129	(+) 3	0.035	sand
	142	(-) 10	1.360	dredged material
	162	(-) 30	1.430	dredged material
97R-B	62	(+) 30	0.096§	sand
	82	(+) 10	0.204	sand
	102	(-) 10	1.410	dredged material
	122	(-) 30	1.550	dredged material
	142	(-) 50	1.310	dredged material
	162	(-) 70	1.470	dredged material
97U-A	121	(+) 30	0.046	sand
	141	(+) 10	0.072	sand
	161	(-) 10	1.150	dredged material
	181	(-) 30	1.650	dredged material
	201	(-) 50	1.420	dredged material

* Samples collected from a 4 cm band surrounding the desired sample depth.

** Distance above (+) or below (-) the sand cap-dredged material interface within the core.

§ Values represent average concentration based on triplicate analysis.

Table 4-4

PCDD/PCDF Summary Statistics for Cap and Dredged Material (Concentration Values in pptr)

NATIVE ISOMERS	Cap Material					Dredged Material				
	Average	Standard Deviation	Maximum	Minimum	Sample Count	Average	Standard Deviation	Maximum	Minimum	Sample Count
2378-TCDF (Furan)	0.35	0.21	0.90	0.13	14	1.1	1.2	4.1	0.075	16
2378-TCDD (Dioxin)	0.31	0.18	0.65	0.090	14	1.7	1.7	7.0	0.15	16
12378-PeCDF	0.22	0.14	0.60	0.070	14	0.90	0.97	3.6	0.17	16
23478-PeCDF	0.24	0.14	0.55	0.055	14	1.0	0.85	2.9	0.22	16
12378-PeCDD	0.36	0.33	1.2	0.085	14	0.79	0.83	3.3	0.070	16
123478-HxCDF	0.30	0.083	0.49	0.19	14	1.6	1.4	4.4	0.24	16
123678-HxCDF	0.34	0.24	0.80	0.055	14	1.1	1.0	4.4	0.29	16
234678-HxCDF	0.38	0.14	0.75	0.18	14	1.2	1.0	3.6	0.32	16
123789-HxCDF	0.28	0.20	0.85	0.070	14	0.79	0.88	3.3	0.21	16
123478-HxCDD	0.32	0.26	0.95	0.085	14	0.70	0.60	2.2	0.31	16
123678-HxCDD	0.27	0.16	0.65	0.085	14	1.0	0.61	2.5	0.26	16
123789-HxCDD	0.22	0.15	0.60	0.065	14	1.01	0.68	2.6	0.26	16
1234678-HpCDF	0.42	0.24	0.95	0.14	14	8.5	9.4	35	0.70	16
1234789-HpCDF	0.37	0.30	1.2	0.12	14	1.2	1.6	6.0	0.22	16
1234678-HpCDD	1.4	0.85	3.7	0.45	14	20	12	52	1.1	16
OCDF	0.91	0.70	2.5	0.18	14	13	12	47	0.90	16
OCDD	12	8.2	32	4.2	14	539	284	890	38	16
TEC	0.90	0.51	2.0	0.34	14	4.3	3.4	14	0.64	16

4.3.3 Average Dioxin/Furan Concentrations for Cap and Dredged Material Units

Dioxin and furan values were averaged for both the cap and the black dredged material using one-half of the detection limit for data below detection (Table 4-4). The average value of dioxin in the cap material was 0.31 ± 0.18 pptr, and the average value in the underlying dredged material was 1.7 ± 1.7 pptr (Table 4-4). Values for detected dioxin in the dredged material ranged from 0.15 to 7.0 pptr. The average furan value in the cap material was 0.35 ± 0.21 pptr, compared with an average of 1.1 ± 1.2 pptr in the underlying dredged material (Table 4-4). Detected values of furan in the cap material ranged from 0.21 to 0.37 pptr, while detected values in the dredged material ranged from 0.24 to 4.1 pptr.

As with the TOC data, dioxin and furan values from the four 1993 Dioxin Project postcap surveys were combined and compared with data from this survey (Figures 4-5 and 4-6, respectively). The average dioxin value for cap material for the May 1999 survey was 0.31 ± 0.18 pptr, slightly higher than the average for the April 1998 postcap survey (0.19 ± 0.075 pptr), but still less than the average value for the 1993 Dioxin Project (0.47 ± 0.75 pptr). The average furan value for the May 1999 postcap survey cap material was 0.35 ± 0.21 pptr, while the average value for the April 1998 postcap survey was 0.26 ± 0.11 pptr and the average furan value for the 1993 Dioxin Project was 0.52 ± 1.0 pptr. The average levels of dioxin and furan in the sand cap were negligible (i.e., less than 1 pptr) for both the 1993 and 1997 projects (Figures 4-5 and 4-6).

Within the DM, the average May 1999 dioxin concentration (1.7 ± 1.7 pptr) was comparable to the April 1998 dioxin concentration (1.5 ± 1.6 pptr) and was much lower than the 1993 Dioxin Project average value (56 ± 41 pptr; Figure 4-5). The average value of furan in the May 1999 samples (1.1 ± 1.2 pptr) was also comparable to the April 1998 furan concentrations (1.0 ± 0.70 pptr) and also was much lower than the 1993 Dioxin Project value (18 ± 12 pptr; Figure 4-6). Thus, it appears based on both the May 1999 one-year postcap and April 1998 first postcap survey results that the 1997 Category II project material was significantly less contaminated than the 1993 project material. The material dredged for the 1997 Capping Project originated from three separate locations. The more contaminated material could have been disposed of first followed by less contaminated material, giving the impression of little or no dioxin and furan contamination in the upper layers of the dredged material mound.

4.3.4 Normalized Concentrations of Dioxin and Furan

Dioxin and furan data for each sediment sample were normalized to TOC because of the different characteristics of each material type. TOC was significantly higher in the DM compared to the cap material (Figure 4-4). Results of normalization of dioxin (ng/kg) to TOC (mg/kg) on a dry weight basis are provided in Tables 4-5a and b. Values below detection were not included in this table. Where the unnormalized results were divided by small fractions of TOC, the normalized values are high.

Dioxin in the cap material sampled in May 1999 was not detected above the required LOD of 1 pptr. Therefore, normalized values were not calculated. Furan was detected in three samples. Normalized furan concentrations ranged from 486 pptr (97U-A, 141 cm) to 725 pptr (97C-A, 104 cm; Table 4-5a).

The minimum value of TOC-normalized dioxin in the DM (Table 4-5b) was measured in Core 97Q-A at 162 cm (10 pptr). The highest value of TOC-normalized dioxin was in the black clayey-silt within Core 97U-A at 201 cm (493 pptr). TOC-normalized furan values in the black clayey-silt material ranged from 17 pptr in sample 97Q-A (162 cm) to 307 pptr in sample 97C-A (184 cm).

4.3.5 2,3,7,8-TCDD Toxic Equivalent Concentrations in Sediments

The concentrations of congeners in sediments have been expressed in terms of 2,3,7,8-TCDD Toxic Equivalents Concentration (TECs; Safe 1990) for each sediment sample (Appendix D). In general, the TEC values mimic those of the raw (i.e., unnormalized) dioxin values. This is not surprising because the TEF for 2,3,7,8-TCDD is one, giving it a larger proportion of the TEC than any of the other congeners (TEFs range from 0.001 to 0.5). TECs are summarized for both material units in Table 4-4. The cap material had the lowest average TEC (0.90 ± 0.51 pptr). The DM had the highest average TEC, but with high variability (4.3 ± 3.4 pptr).

Table 4-5a

PCDD/PCDF Concentrations Normalized to Total Organic Carbon (Dry Weight) for Cap Material

	97B-B			97C-A		97E-A		97Q-A			97R-B		97U-A	
	Cap	Cap	Cap	Cap	Cap	Cap	Cap	Cap	Cap	Cap	Cap	Cap	Cap	Cap
Sample Depth (cm)	110	130	138	104	124	138	158	102	122	129	62	82	121	141
2378-TCDF (Furan)			512	725										486
2378-TCDD (Dioxin)														
12378-PeCDF														
23478-PeCDF														
12378-PeCDD														
123478-HxCDF	244	926	537	647										
123678-HxCDF		852												
234678-HxCDF	436	1111	854	804			557		1000				848	472
123789-HxCDF														
123478-HxCDD														
123678-HxCDD														
123789-HxCDD														
1234678-HpCDF			1146	1333					1432					
1234789-HpCDF														
1234678-HpCDD	1231	2593	4146	3529	1811		2295	3083	5682	1286			1891	1236
OCDF			2195	2353	962				5682	1457				
OCDD	7436	18519	48780	27451	22642	10727	21311	26667	50000	31429	5538	2059	10435	9861
TEC	632	1276	1063	1207	1065	3537	1556	1684	1602	2471	1127	510	2035	922

Table 4-5 b

PCDD/PCDF Concentrations Normalized to Total Organic Carbon (Dry Weight) for Dredged Material.

	97B-B		97C-A			97E-A		97Q-A		97R-B				97U-A		
	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM	DM
Sample Depth (cm)	150	170	144	164	184	178	198	142	162	102	122	142	162	161	181	201
2378-TCDF (Furan)					307	55		45	17	59			68	139	194	169
2378-TCDD (Dioxin)	446	20			247	130		65	10	135	110		102	226	85	493
12378-PeCDF	47				142	21							37	104	218	
23478-PeCDF					180	21		47					31	139		
12378-PeCDD																
123478-HxCDF	347	34			194	69						191		304	255	
123678-HxCDF	520				75	64		32					46	148	267	
234678-HxCDF	153			80	82	35		66		70	71	99	68	174	206	
123789-HxCDF																
123478-HxCDD		24			40									50		
123678-HxCDD		36			127	66		67					75	165		
123789-HxCDD		51			90	66							56	130		
1234678-HpCDF	1213	95	271	95	748	313		324		688	561	519	442	1217	1515	2465
1234789-HpCDF						17								113		
1234678-HpCDD	2723	1299	1938	371	2094	1374	69	1618	126	1348	1484	1985	1156	2348	1697	3662
OCDF	3465	112	685	181	1346	840		551		1064	839	1069	748	1739	1758	3310
OCDD	49505	41937	73643	11207	53852	37405	4340	54412	2657	45390	41935	61069	31293	55652	53333	62676
TEC	810	129	221	114	540	263	81	218	45	342	289	334	221	533	466	1001

Note: Values were not calculated for results below detection. Data are provided on a dry weight basis and are given in terms of ng congener/kg TOC.

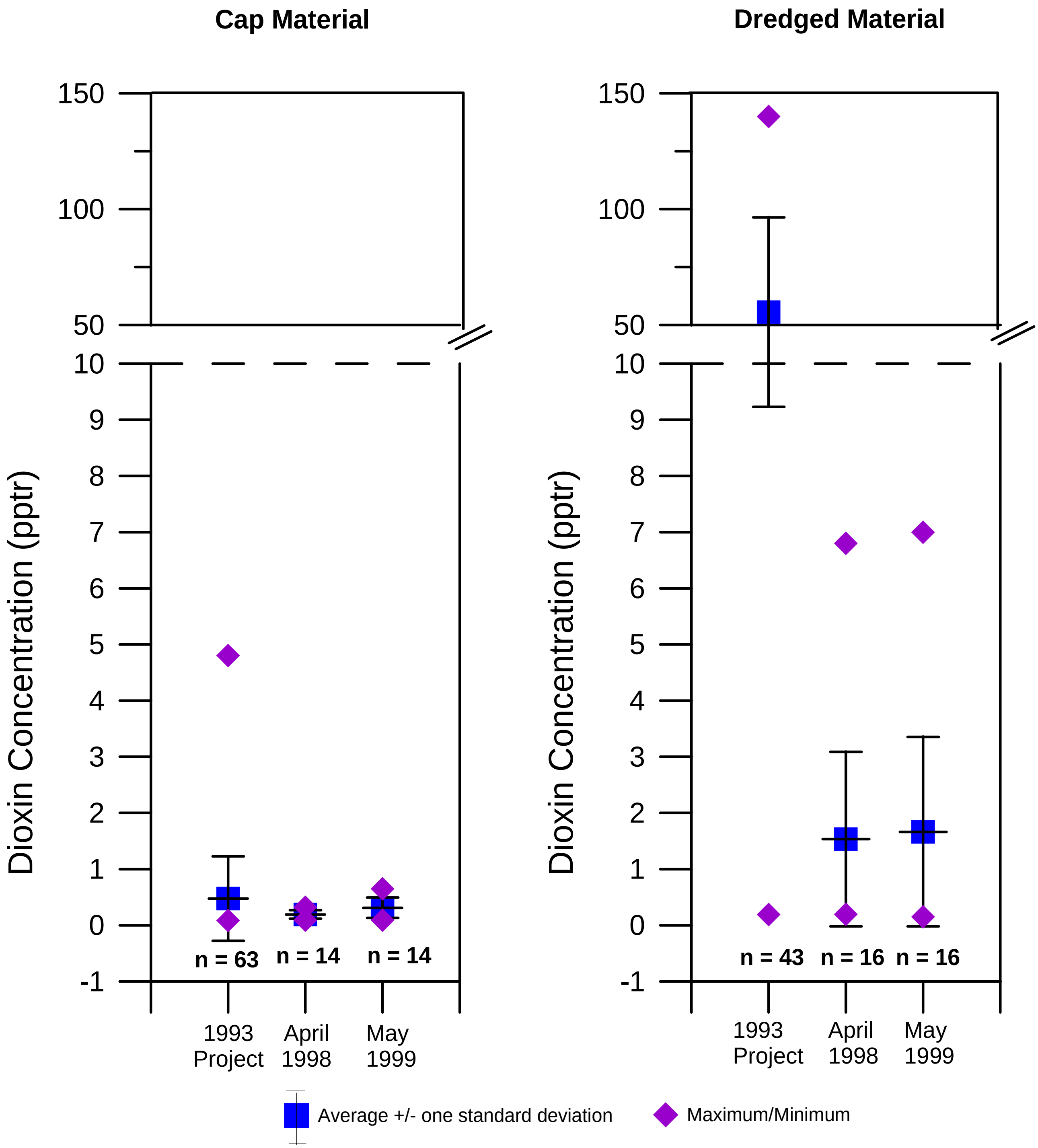


Figure 4-5. Comparison of average dioxin concentration in cap material (left graph) and dredged material (right graph) between the April 1998 and May 1999 postcap coring surveys of the 1997 Category II Capping Project and the 1993 Dioxin Capping Monitoring Project.

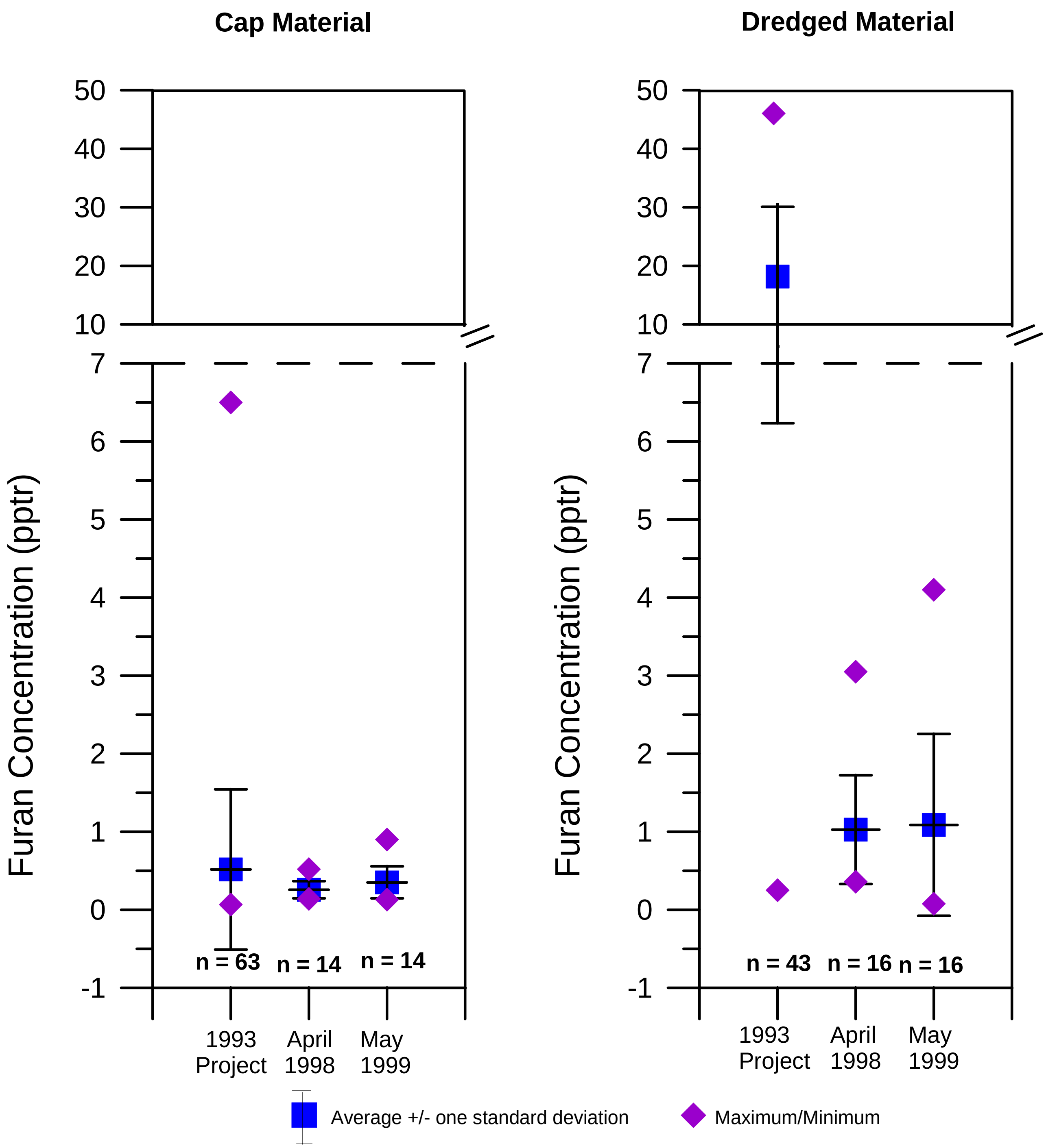


Figure 4-6. Comparison of average furan concentration in cap material (left graph) and dredged material (right graph) between the April 1998 and May 1999 postcap coring surveys of the 1997 Category II Capping Project and the 1993 Dioxin Capping Monitoring Project.

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5.0 DISCUSSION

5.1 Discussion of the Geotechnical Analysis Results

5.1.1 Summary of the 1997 Category II Capping Project Geotechnical Studies

The geotechnical investigation of the 1997 Category II Capping Project began in December 1996, when WES obtained measurements of the pre-dredged *in situ* geotechnical properties of material from Port Newark and Port Elizabeth Marine Terminals (Figure 5-1). This information was collected in order to aid in the project design (Rollings and Rollings 1998a). Ultimately, the material dredged originated from three locations: Reach "D" for Sealand Shipping, the loading facility in Tremley Point Reach for Citgo Oil Company, and the construction of the Newark Bay Confined Disposal Facility (CDF; Figure 5-1, SAIC 1997c). These data, however, still provided a relative baseline for the project.

In May 1997, a baseline sediment coring survey was conducted to provide a description of the seafloor material within the proposed disposal location (SAIC 1998c). The most common material observed was a medium- to fine-grained gray sand, with relatively low water content (average 19.4%). Some silt and clay was noted in cores collected at stations along the northwest half of the sampling transect (Figure 2-1, cores 97A-97F) where historical dredged material had been disposed (e.g., Williams and Duane 1974). In fact, Category I material was disposed to the north of the 1997 Category II Capping Project area within two years prior to the disposal phase of this project. The average water content value for the pre-project silty material (63.4%) was higher than that of the sandier material, a result which was consistent both with the dominant fine grain size, and the potential presence of recently disposed Category I dredged material to the north of the project area.

In both the interim (July 1997; SAIC 1998h) and postdisposal (August 1997; SAIC 1998g) sediment coring surveys, the goal was to monitor changes in the geotechnical properties of the project dredged material from the time it was disposed until capping operations began. When sediments are dredged and re-deposited, they are initially bulked due to the entrainment of water during the process (SAIC 1997d, Rollings and Rollings 1998b). In the time period between the dredged material's initial deposition at the site and the placement of capping material, self-weight consolidation begins to occur, though at a much slower rate than consolidation under overburden conditions (i.e., once capping material is placed). As sediments consolidate, water is forced out from the compacting pore spaces, decreasing both the material's water content and void ratio, and increasing its bulk density. While such trends were seen in the measured values of these two surveys (Table 5-1, Figure 5-2), especially between the August 1997 postdisposal and April 1998 postcap surveys, a two-tailed t-test, assuming unequal variances, showed that these changes were not statistically significant.

The lack of statistical changes in physical properties does not prove that self-weight consolidation was not an active process at the dredged material mound. Rather, it is indicative of the difficulty of measuring geotechnical properties of highly heterogeneous disposed dredged material immediately after deposition. The initial void ratio data were collected on

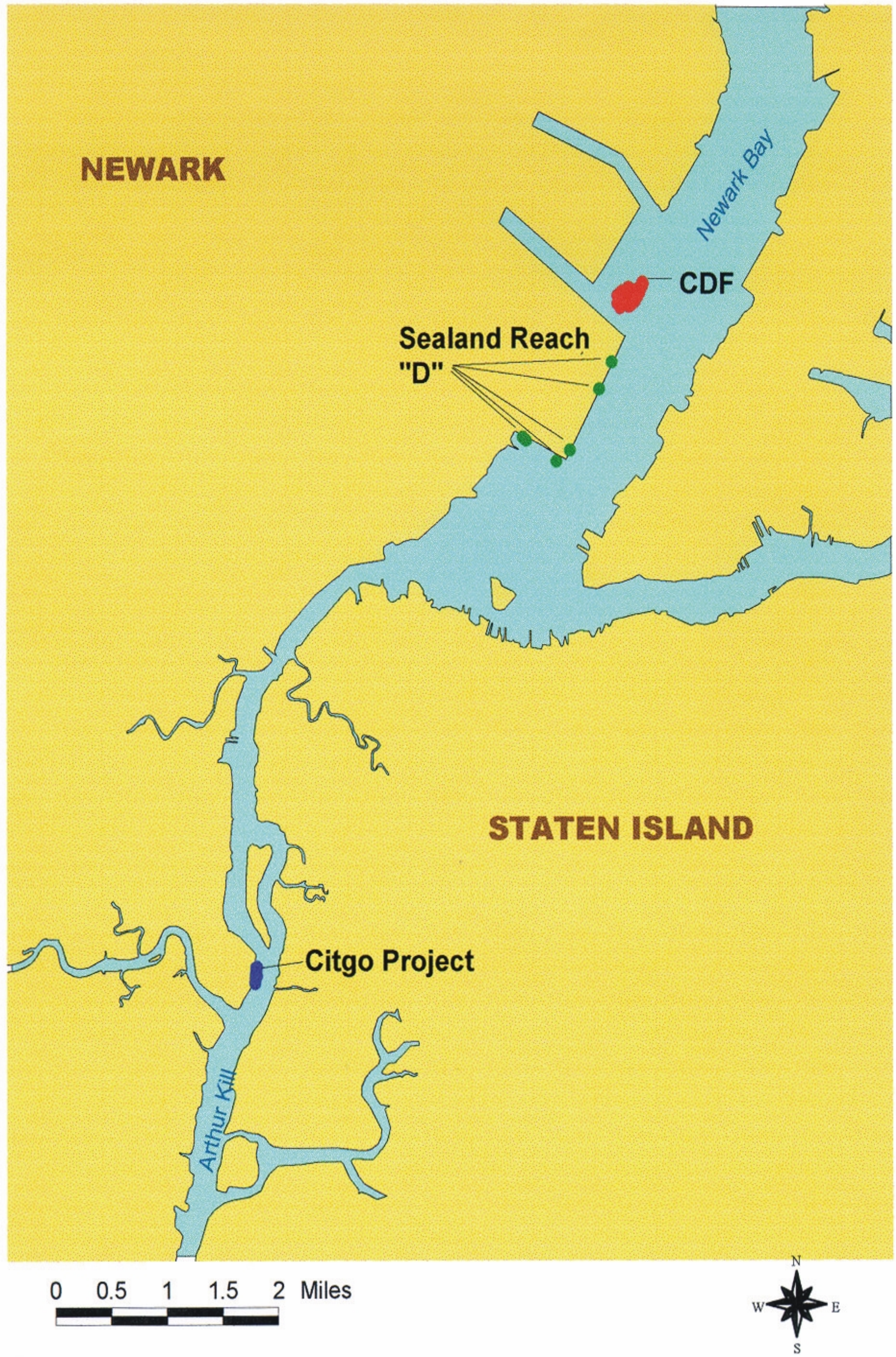


Figure 5-1. Dredging sites for the 1997 Category II Capping Project, as determined by NYDISS.

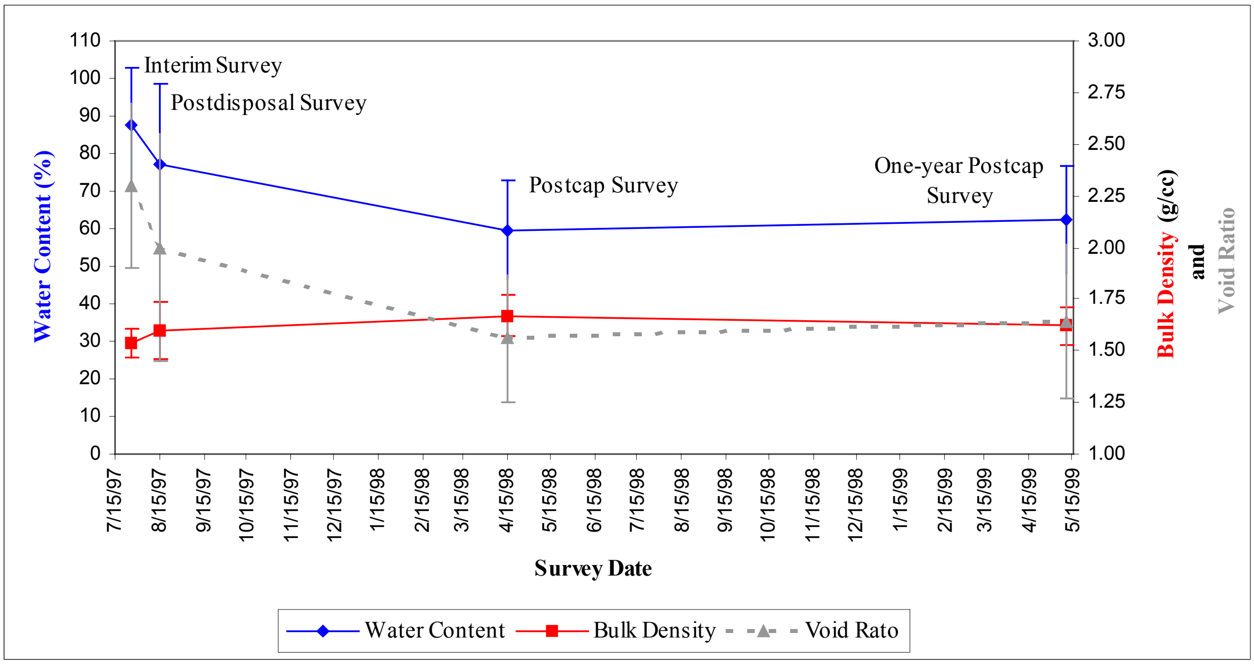


Figure 5-2. Change in average water content, bulk density, and void ratio values for the dredged material unit throughout the 1997 Category II Capping Project sediment coring surveys.

Table 5-1

Average Water Content, Bulk Density, and Void Ratio Values for the DM Unit for 1997 Category II Capping Project Sediment Coring Surveys

	Interim Disposal	Postdisposal	Postcap	One-Year Postcap
Water Content (%)	87.6	77.1	59.7	62.5
Bulk Density (g/cc)	1.54	1.60	1.67	1.62
Void Ratio	2.30	2.00	1.56	1.64

dredged material placed anytime between 0 and 61 days of the project. This suggests the samples were collected from sediment in various phases of self-weight consolidation.

Both of these datasets also provided invaluable information about the project material's physical properties during all phases of the project. By using these data as groundtruth for modeling, long-term changes in the material can be monitored, and enhance the understanding of consolidation and material behavior within a capped disposal mound.

In April 1998, the first postcap coring survey was conducted, following the completion of capping activities. Past studies have shown that consolidation due to overburden conditions (i.e., placement of sand cap material) starts out very rapidly and then slows to an almost undetectable rate as time progresses (Poindexter-Rollings 1990). A smaller-scale capping project in Long Island Sound showed that 90% of dredged material consolidation occurred within the first 100 days following the sand cap placement (Poindexter-Rollings 1990). The capping operations for the 1997 Category II Capping Project began in August 1997, and concluded on January 18, 1998. The period, therefore, over which postcap consolidation had occurred prior to sample collection was at least three months, suggesting that the most rapid phase of consolidation had already taken place. As expected, statistically significant changes in the water content and void ratio values were observed in the April 1998 postcap survey (SAIC 1998b).

This, the one-year postcap coring survey, was the second look at the 1997 Category II Capping Project disposal mound sediment properties since final placement of the sand cap material occurred. The data collected in this survey was intended to further monitor and ensure cap effectiveness, and allow for the evaluation of changes in the capped dredged material's physical properties since disposal. Statistically, measured values of water content, bulk density, and void ratio remained the same (Table 5-1, Figure 5-2), indicating that no significant consolidation has occurred within the mound over the last year. These trends are consistent with consolidation models (rapid consolidation at first and then slowing with time), and suggest that material properties are related to the consolidation state (Poindexter-Rollings 1990). No significant changes should be expected in the future.

5.1.2 Cap Stability

Often the possibility of mixing between the higher density sand cap and lower density fine-grained dredged material is a concern, bringing into question the stability of the cap. All cores collected during the initial postcap coring survey in April 1998 exhibited distinct sand cap/dredged material interfaces. The average thickness of the sand cap for the 14 cores collected in the April 1998 survey was 179 cm (Table 5-2). In the one-year postcap coring survey, clearly defined interfaces were again observed. In addition, the thickness of the sand cap exceeded 100 cm in all cores except one (92 cm), with the overall average thickness determined to be 153 cm (Table 5-2). In both surveys, there was considerable variability in sand cap thickness among cores collected at different stations and between replicate cores collected at individual stations. However, the overall average sand cap thickness measured in the May 1999 one-year postcap survey had not changed appreciably from that observed in April 1998 (Table 5-2). This is evidence that the sand cap has remained stable and has not experienced significant erosion since its placement in early 1998.

While sand was noted along the core edge within the first few centimeters of the DM unit for some cores, this was a result of "drag-down" in which the coring device tends to pull some material with it as it penetrates the sediments. This is not an indication of cap instability. As time has progressed, the DM unit of the cores has been noted as being firmer in texture, and exhibited lower water content and liquid limit values. These changes are a direct result of the compaction and consolidation occurring within the dredged material from the load of the sand cap, and results in greater material stability. All indications are that the sand cap is very stable and it is unlikely that any future mixing between the two materials will be observed.

Table 5-2

Comparison of Measured Sand Cap Thickness between the April 1998 Postcap and May 1999 One-Year Postcap Coring Surveys.

Station	Measured Sand Cap Thickness within Core (cm)	
	April 1998	May 1999
97A	167	106
97B	133	140
97C	146	134
97D	225	126
97E	116	168
97L	228	221
97O	245	148
97P	257	190
97Q	120	132
97R	126	92
97S	194	158
97T	229	150
97U	176	151
97V	150	229
Average ± 1 s.d.	179 ± 50	153 ± 39

5.2 Discussion of Chemical Analysis Results

5.2.1 Total Organic Carbon

Total organic carbon values for the May 1999 survey generally were consistent with what would be expected for this project. The average TOC value for the cap unit was consistent with and within one standard deviation of values from the 1993 Dioxin Capping Project and the April 1998 postcap survey (Figure 4-4). The average TOC value for the May 1999 dredged material unit was somewhat lower than the values for the 1993 project and April 1998 survey. This is consistent with anaerobic decomposition of organic carbon as the sediments have become reduced beneath the sand cap.

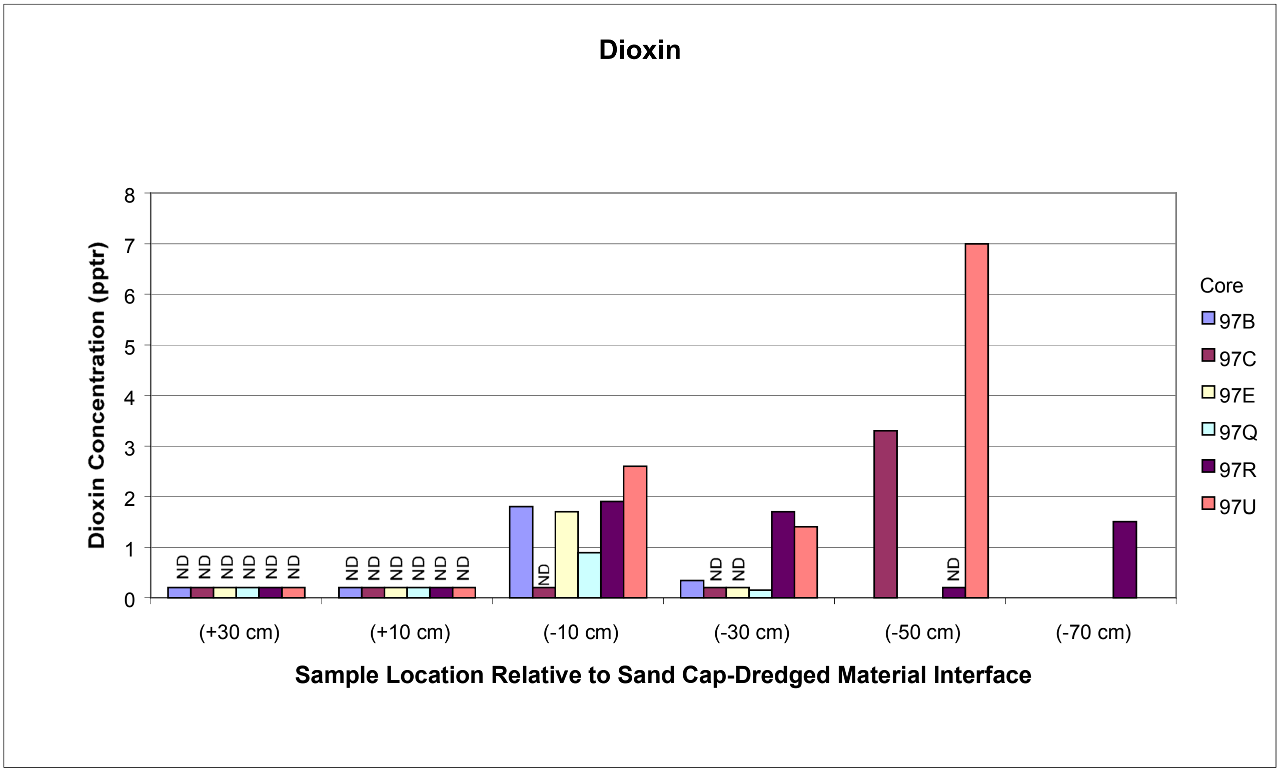
5.2.2 Dioxin and Furan

The purpose of the sand cap was to provide a clean (Category I) containment method for the underlying Category II disposed material. The sand used for capping of both the 1997 Category II Project and the earlier 1993 Dioxin Capping Project was dredged from Ambrose Channel after first having been characterized as Category I; therefore, dioxin and furan were not expected to be detected within the cap material above ambient concentrations of less than 1 pptr measured in the New York Bight area (SAIC 1991; SAIC 1998a). Figures 4-5 and 4-6 illustrate the negligible concentrations of dioxin and furan within the cap material during both the 1993 Dioxin Capping Project and 1997 Category II Project. For the 1997 Category II Project, therefore, these results support the conclusion that the newly-placed cap was effectively isolating underlying contaminants known to be present, albeit at low concentrations, in the underlying material.

Based on the pre-dredging characterization of the 1997 project material as Category II, it is reasonable to expect that elevated concentrations of dioxin and furan would be measured in the samples of this material obtained during the May 1999 coring survey. However, the concentrations detected in the one-year postcap core samples were quite low, similar to the concentrations measured in the first postcap survey. These low concentrations were in contrast to the DM values measured during the 1993 Dioxin Capping Project. As illustrated in Figure 4-5, the average value of dioxin measured in the 1997 project material was 1.7 pptr, which was significantly lower than the overall average of 56 pptr for the 1993 project material. Likewise, there was a large difference in average measured furan values between the 1997 and 1993 projects (Figure 4-6). Overall, these results indicated that the 1997 project material had relatively low levels of both dioxin and furan, particularly compared to the 1993 project material. Given these relatively low concentrations, it is anticipated that future monitoring will reveal no appreciable levels of either contaminant in the overlying cap.

The variation of dioxin and furan concentrations with core depth, particularly with respect to the sand cap-dredged material interface, was also examined (Figure 5-3). This figure provides a visual example of the inhomogeneity of the project material both within an individual core and among cores. In addition, the concentrations of both dioxin and furan increased below the sand cap-dredged material interface. This was consistent with the most contaminated sediments being placed first.

In conclusion, the chemistry results for the May 1999 one-year postcap coring survey showed that the sand cap has been effective in containing the underlying dioxin and furan contaminated Category II dredged material. Both dioxin and furan were essentially not detected within the cap material (Figure 5-3). Dioxin and furan were detected within the dredged material but at concentrations of less than 7 pptr. At such low concentrations in the underlying material, it is unlikely that appreciable concentrations of either dioxin or furan will be observed in the sand cap in future monitoring efforts.



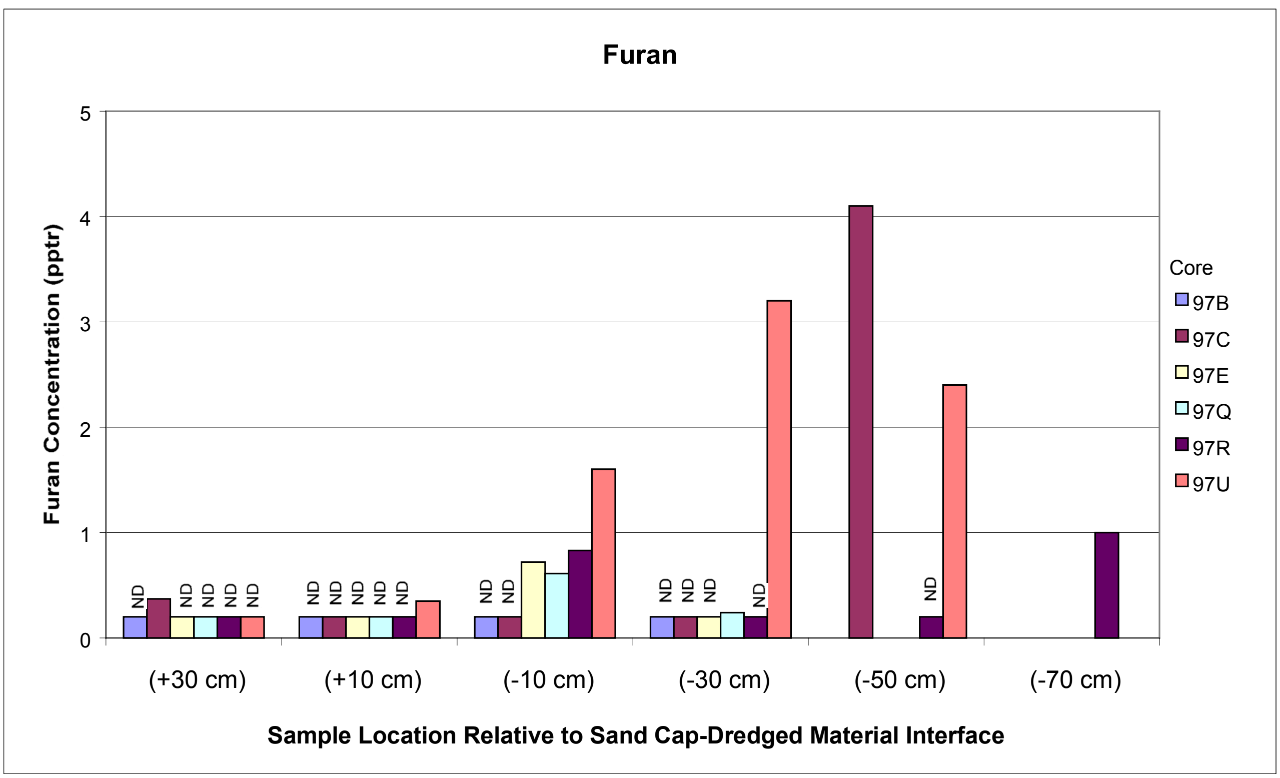


Figure 5-3. Intercore comparison of dioxin and furan concentrations. ND indicates not detected in this sample.

6.0 SUMMARY

- **Was it possible to identify an interface between the sand cap and the underlying dredged material in the cores?**

Based on grain size as well as color and texture, the transition from cap to dredged material was clearly visible in all cores for which DM was penetrated. In most cases, this was a very distinct, sharp boundary; however, sand was noted along the outer edge of the dredged material for the first few centimeters for several of the cores. This is attributed to drag-down during the coring process rather than reflecting instability at the cap-dredged material boundary. The interface was also clearly identifiable through the various geotechnical properties measured.

- **Was there variability in either the cap or the underlying dredged material?**

Overall, both the cap and DM layers were composed of relatively homogenous material types. The sand cap was comprised of medium to coarse sand ranging from dark gray to grayish brown and brownish gray in color. The DM unit had a wide range of physical properties, but could not be categorized into distinct sub-categories. In general, the DM unit consisted of fine-grained black clayey silt with some patches of fine-grain sand and red clay.

- **Were there any visual indications of significant sand cap erosion or mixing (instability) between the sand cap and dredged material?**

The overall average sand cap thickness measured in the May 1999 one-year postcap survey had not changed appreciably from that observed in April 1998. This is evidence that the sand cap has remained stable and has not experienced significant erosion since its placement in early 1998.

The possibility of mixing between the higher density sand of the cap and the lower density, fine-grained dredged material has been a concern of this and other capping projects. The cores from the April 1998 project showed an undisturbed boundary between the sand and finer-grained project material, with no obvious indications of mixing between the two layers. The same observation was again made in this, the one-year postcap coring survey. In several cores, there was sand along the sides of the top layer of dredged material in the core liner. This is attributed to drag-down during the coring process.

- **Do the geotechnical properties of the in-place cap material and the underlying dredged material suggest that these materials are internally stable?**

There was no geotechnical evidence of instability across the cap/dredged material interface due to either consolidation or loading of the higher density sand cap over lower density dredged material. The core profiles of density and water content all showed a distinct difference between the cap and dredged material. Within the cores, there was no evidence of mixing between the layers which would be seen if the sand had collapsed into the underlying, more fluid, fine-grained material. Large-scale deformations caused by loading sand over silt and clay could not, however, be measured by the limited horizontal resolution of the relatively narrow cores.

- **Is there evidence of dredged material consolidation?**

As sediment consolidates, water is extruded from the compacting pore spaces, resulting in decreased water content and void ratio values, and increased bulk density values, over time. After an initial steep rate of change in consolidation after capping, the rate of consolidation slows dramatically until the change is below the resolution of measurement techniques (Poindexter-Rollings 1990).

Statistically significant changes in water content and void ratio values between the postdisposal and postcap coring surveys were observed, and were evidence that consolidation had occurred since the loading of the sand cap material. As expected, the rate of consolidation has appeared to slow, and no statistically significant changes in the dredged material or sand cap were observed in this one-year postcap coring survey.

- **Was there any dioxin or furan present in the cap material?**

Both dioxin and furan were essentially undetected in the cap material. The lack of any dioxin or furan above the required detection limit of 1.0 pptr in the sand cap suggests that this newly-placed cap was being effective in isolating the underlying contaminated dredged material at the time of the May 1999 one-year postcap coring survey.

- **Have the chemical concentrations in the cap or dredged material units varied over time among the two postcap surveys?**

Dioxin and furan within the cap material, as stated above, were below detection in both the April 1998 and May 1999 postcap surveys. Within the underlying dredged material, dioxin and furan concentrations were barely above detection in both surveys. The maximum values in the May 1999 one-year postcap survey were 7.0 and 4.1 pptr for dioxin and furan, respectively. These are considered to be very low concentrations indicative of only mild contamination of the 1997 Category II Capping Project material.

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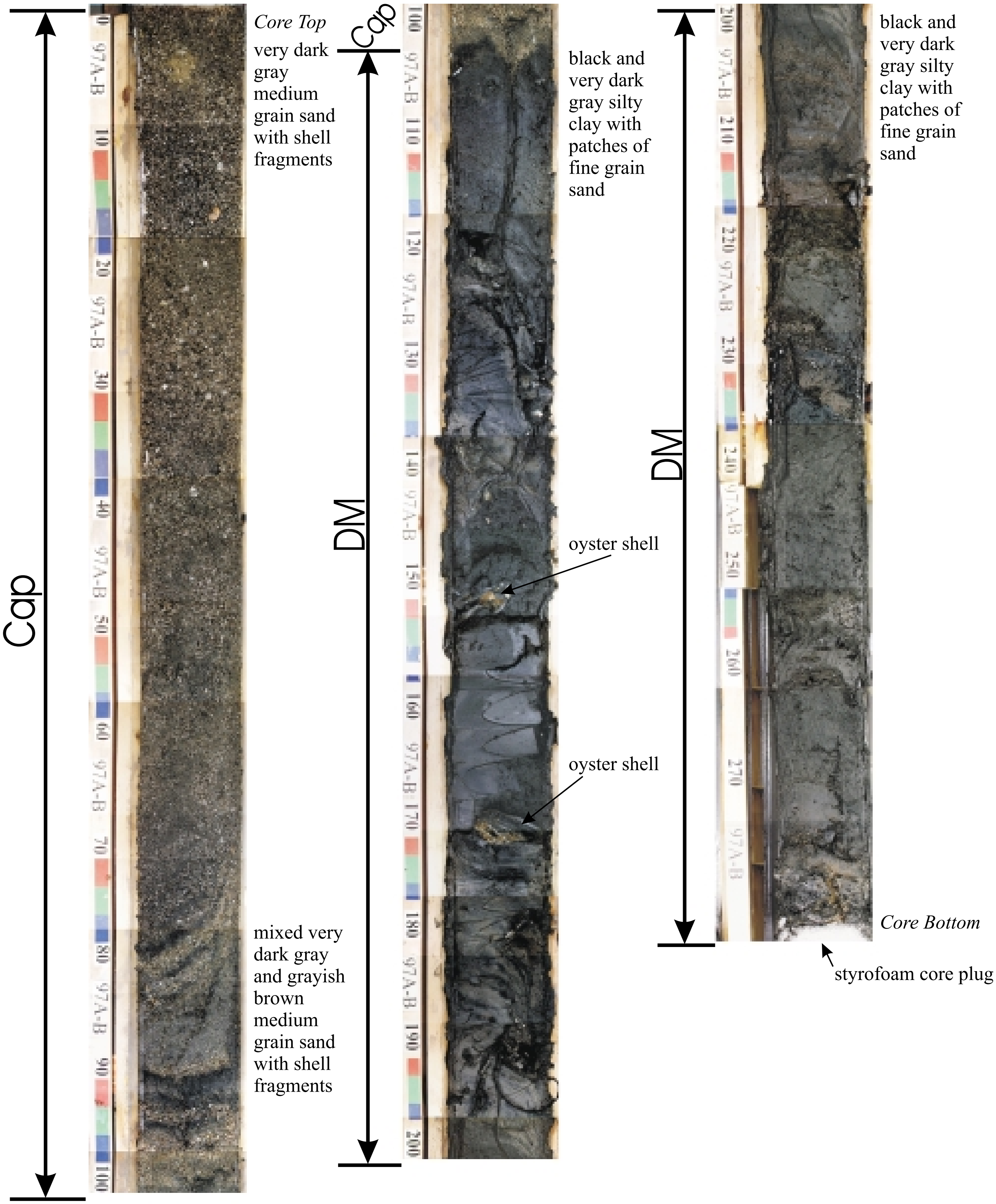
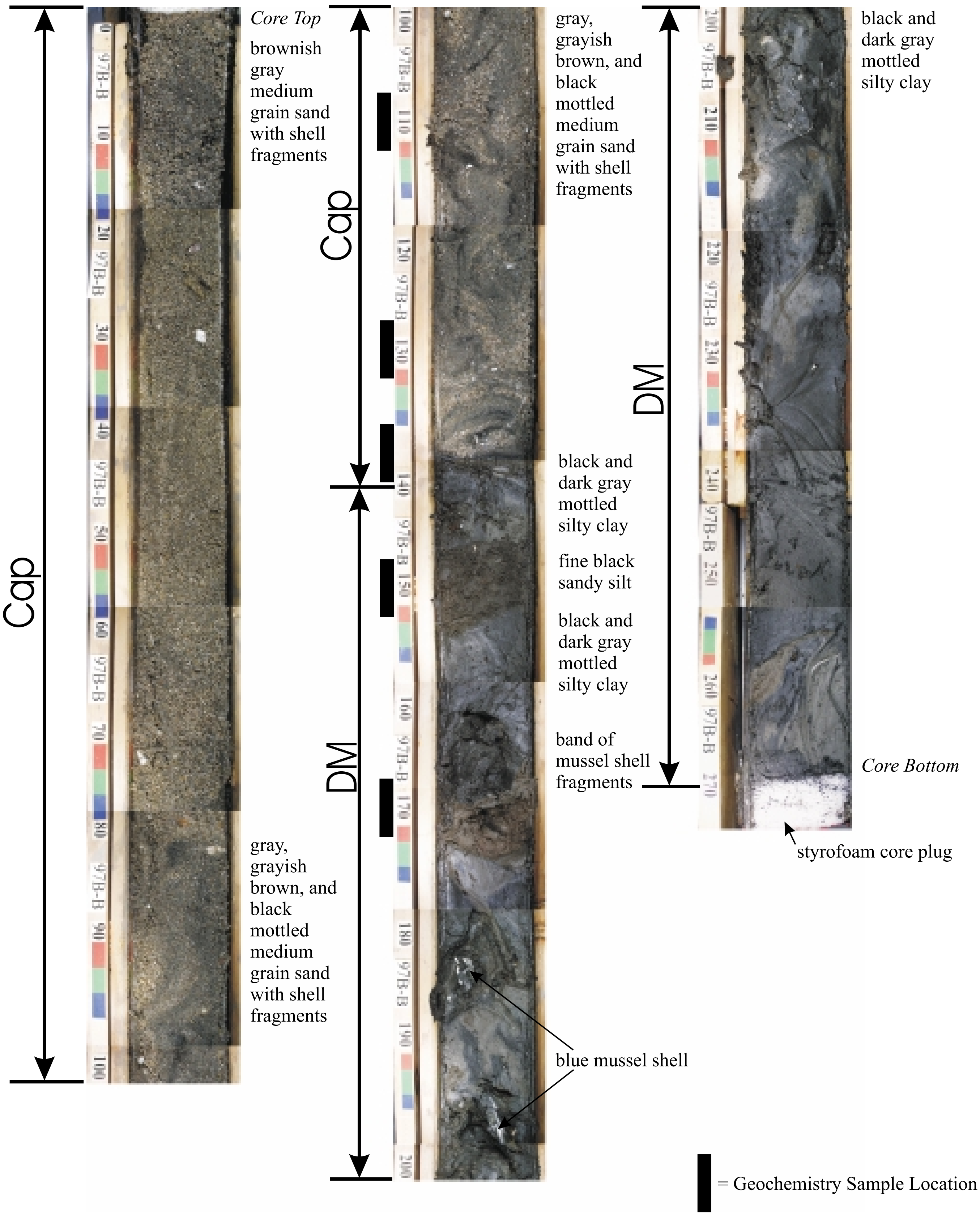
APPENDIX A
Core Logs

Core 97A-B

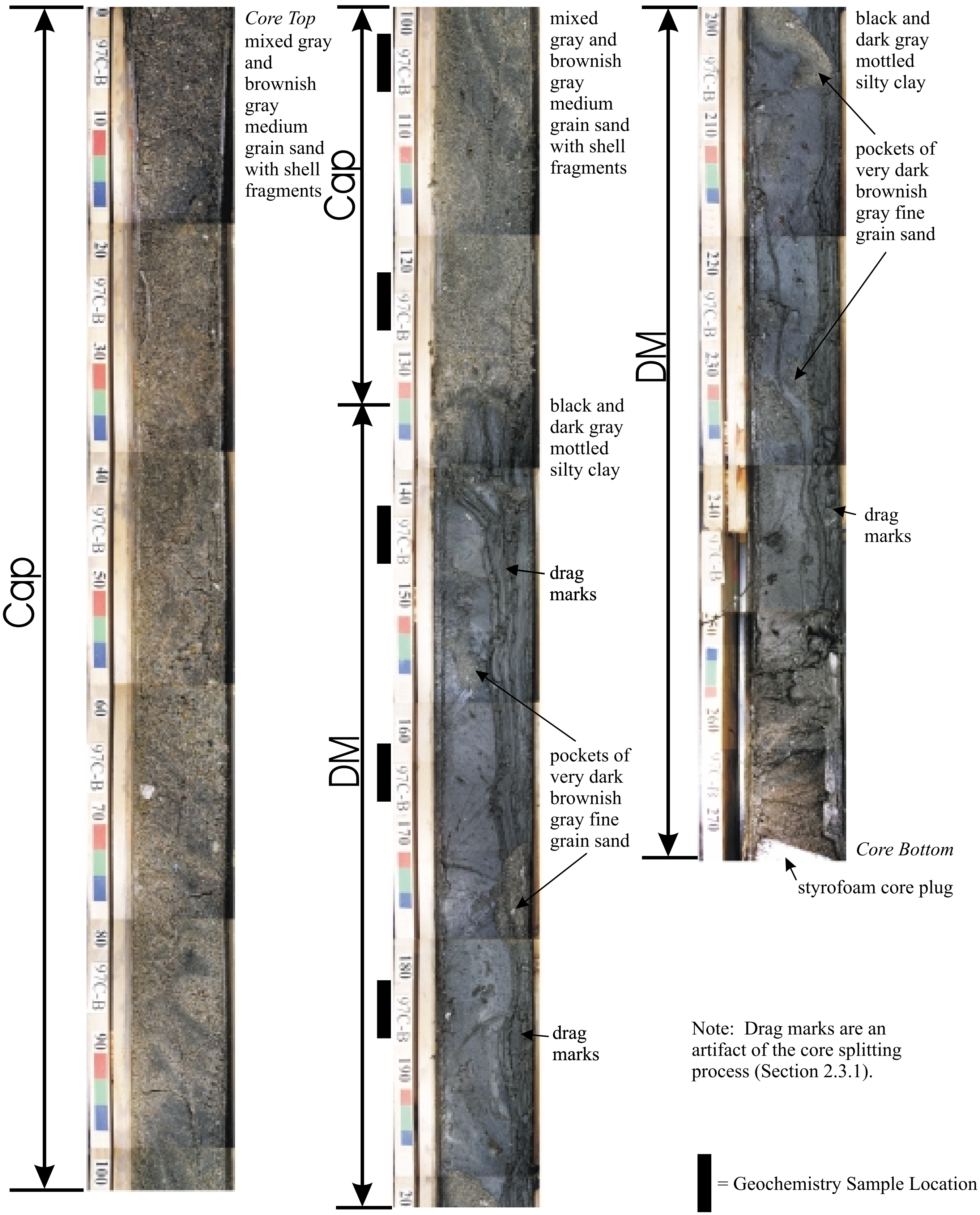

Core Top
very dark gray medium grain sand with shell fragments
Cap
mixed very dark gray and grayish brown medium grain sand with shell fragments
Cap
DM
black and very dark gray silty clay with patches of fine grain sand
oyster shell
oyster shell
DM
black and very dark gray silty clay with patches of fine grain sand
Core Bottom
styrofoam core plug

Core 97B-B

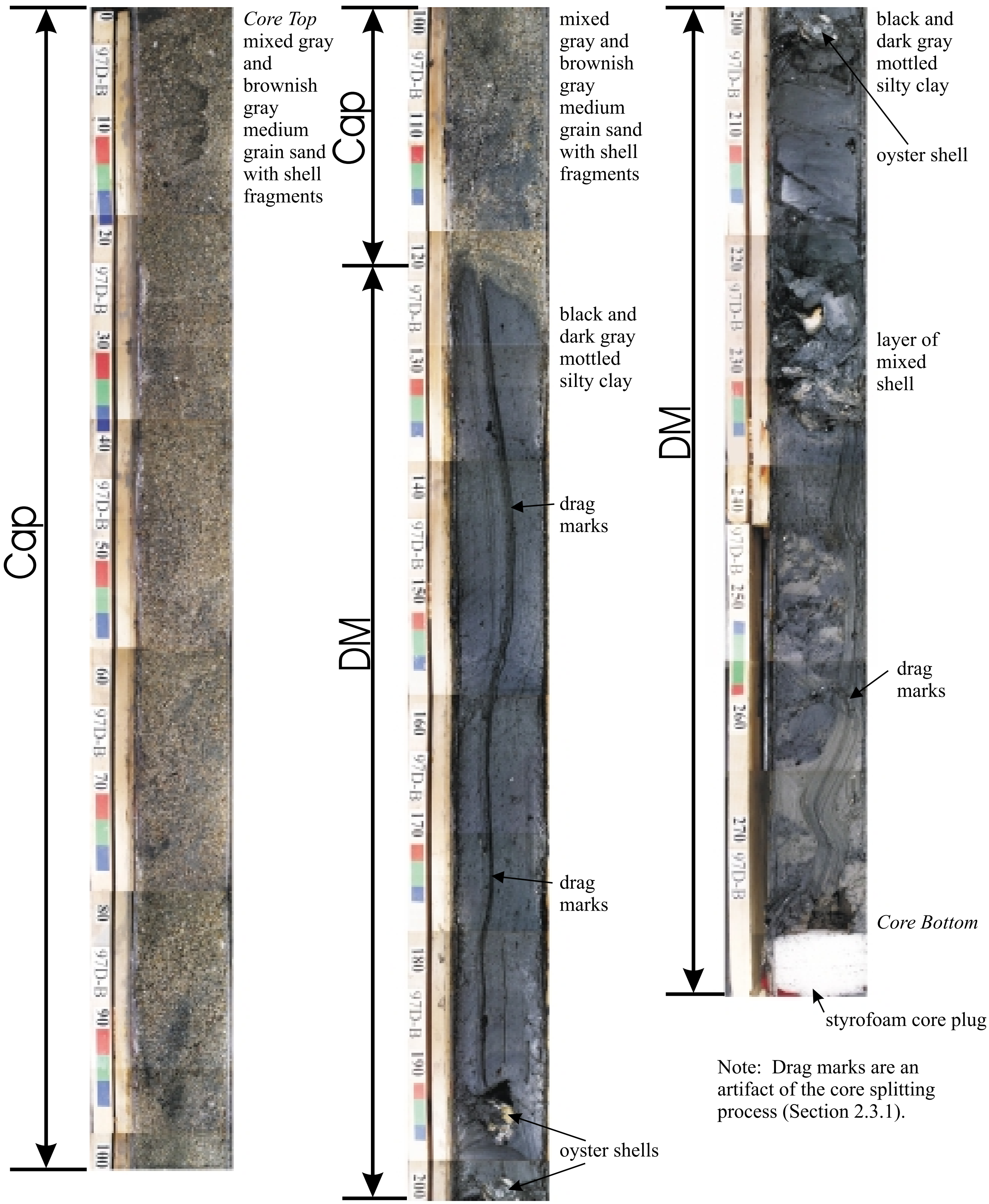


Cap
Core Top
brownish gray medium grain sand with shell fragments
gray, grayish brown, and black mottled medium grain sand with shell fragments
Cap
gray, grayish brown, and black mottled medium grain sand with shell fragments
black and dark gray mottled silty clay
fine black sandy silt
black and dark gray mottled silty clay
band of mussel shell fragments
DM
blue mussel shell
DM
black and dark gray mottled silty clay
Core Bottom
styrofoam core plug
= Geochemistry Sample Location

Core 97C-B

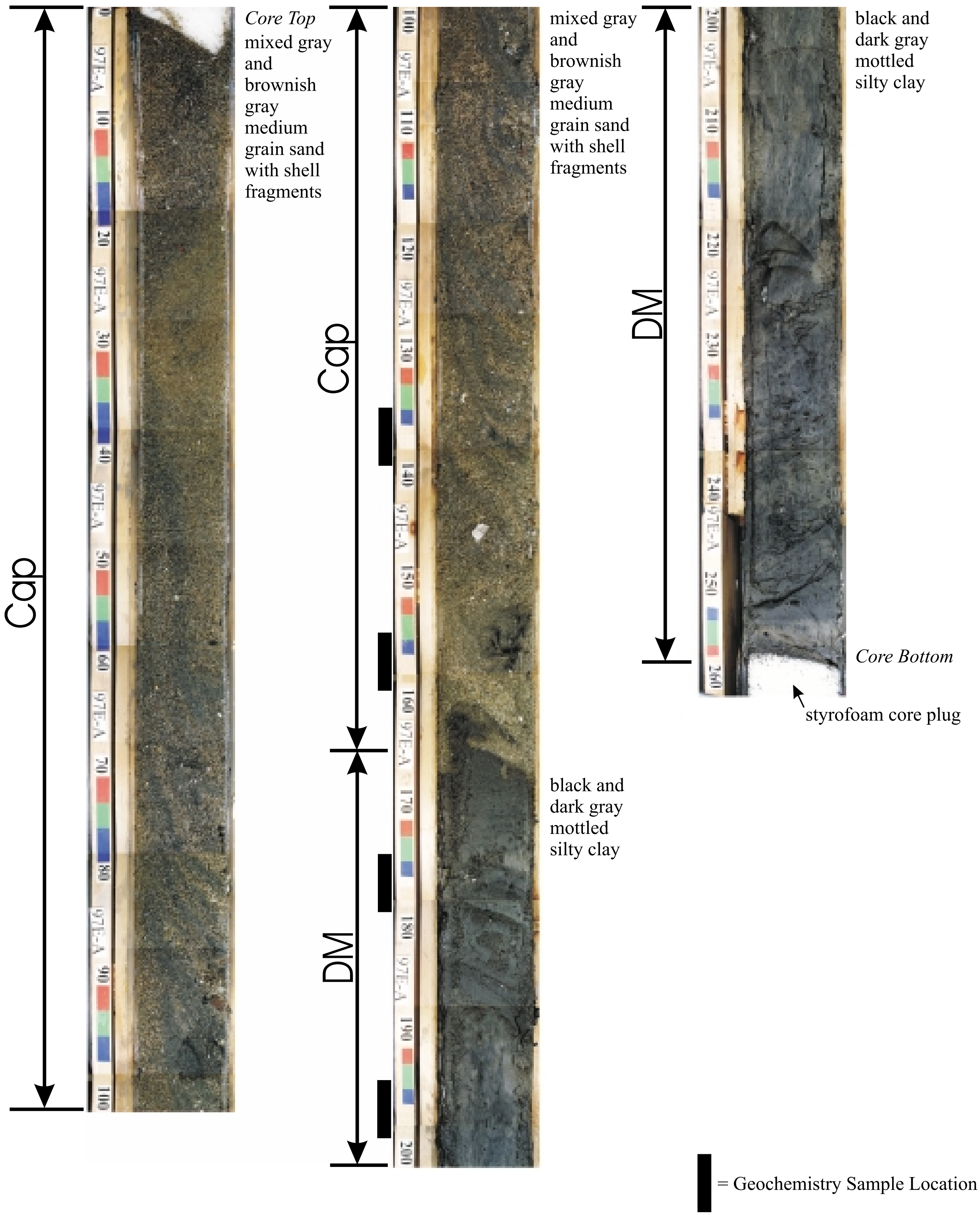

Cap
Core Top
mixed gray and brownish gray medium grain sand with shell fragments
Cap
mixed gray and brownish gray medium grain sand with shell fragments
DM
black and dark gray mottled silty clay
drag marks
pockets of very dark brownish gray fine grain sand
drag marks
DM
black and dark gray mottled silty clay
pockets of very dark brownish gray fine grain sand
drag marks
Core Bottom
styrofoam core plug
Note: Drag marks are an artifact of the core splitting process (Section 2.3.1).
= Geochemistry Sample Location

Core 97D-B



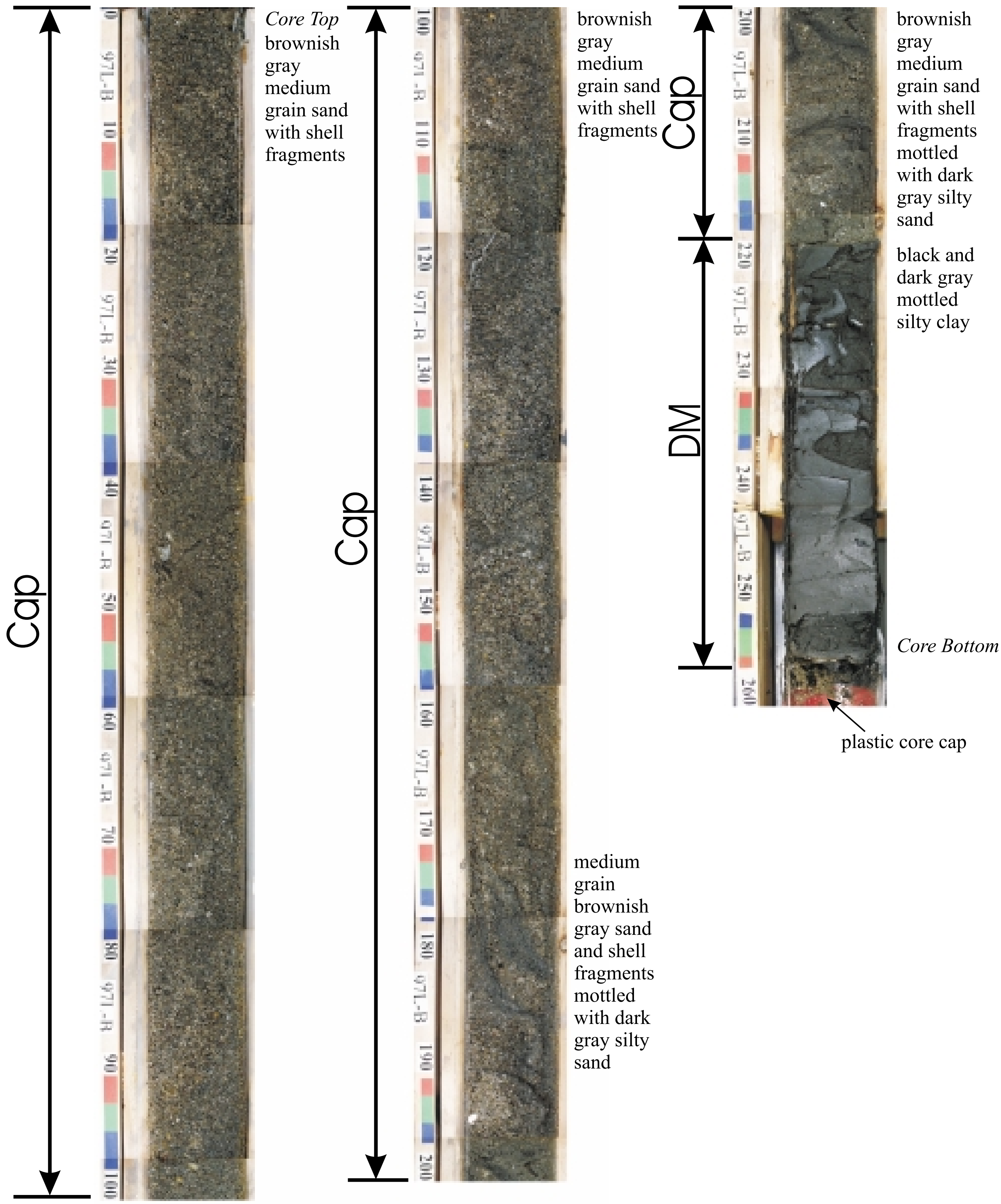
Note: Drag marks are an artifact of the core splitting process (Section 2.3.1).

Core 97E-A



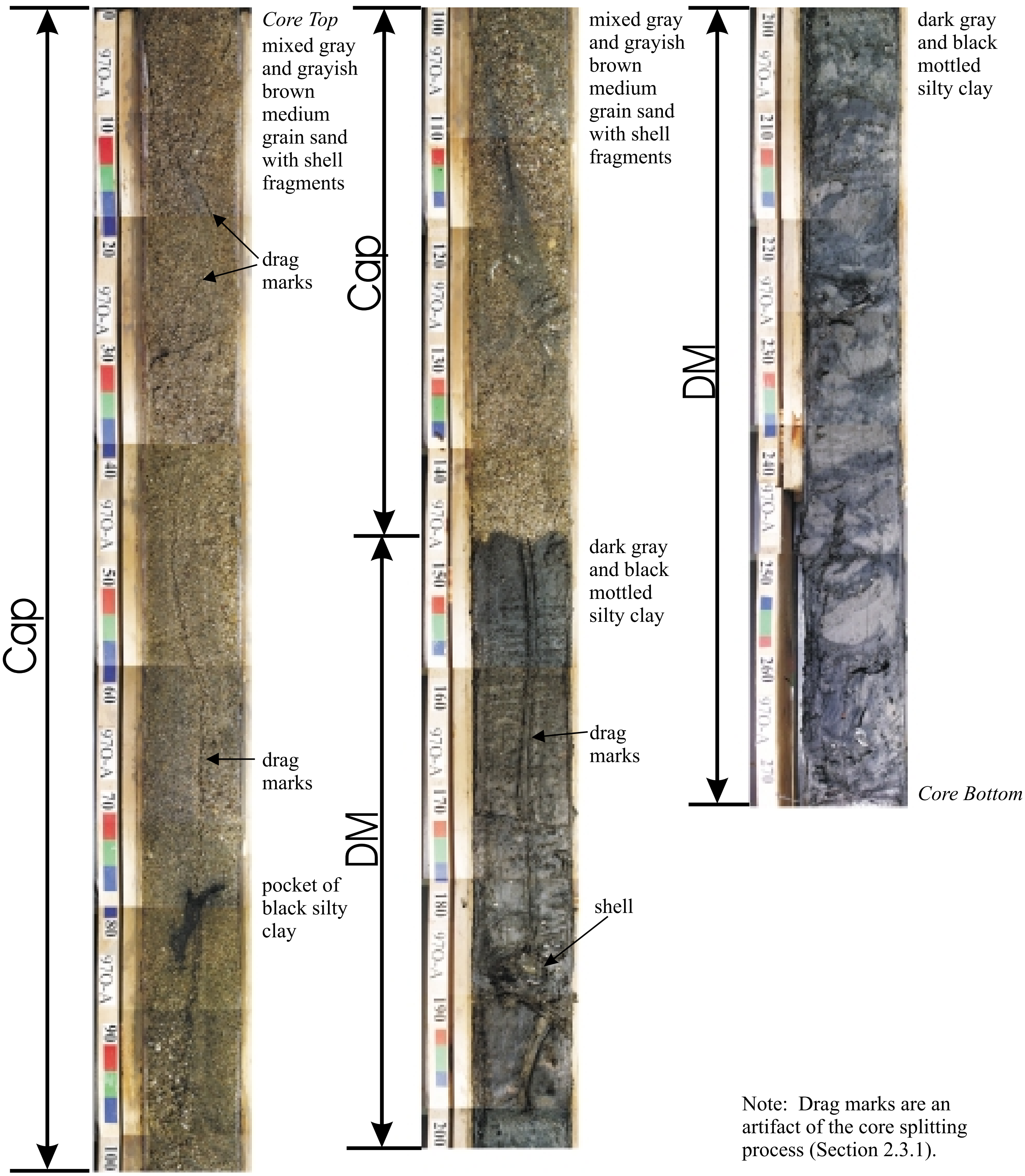
Cap
Core Top
mixed gray and brownish gray medium grain sand with shell fragments
Cap
mixed gray and brownish gray medium grain sand with shell fragments
DM
black and dark gray mottled silty clay
DM
black and dark gray mottled silty clay
Core Bottom
styrofoam core plug
= Geochemistry Sample Location

Core 97L-B



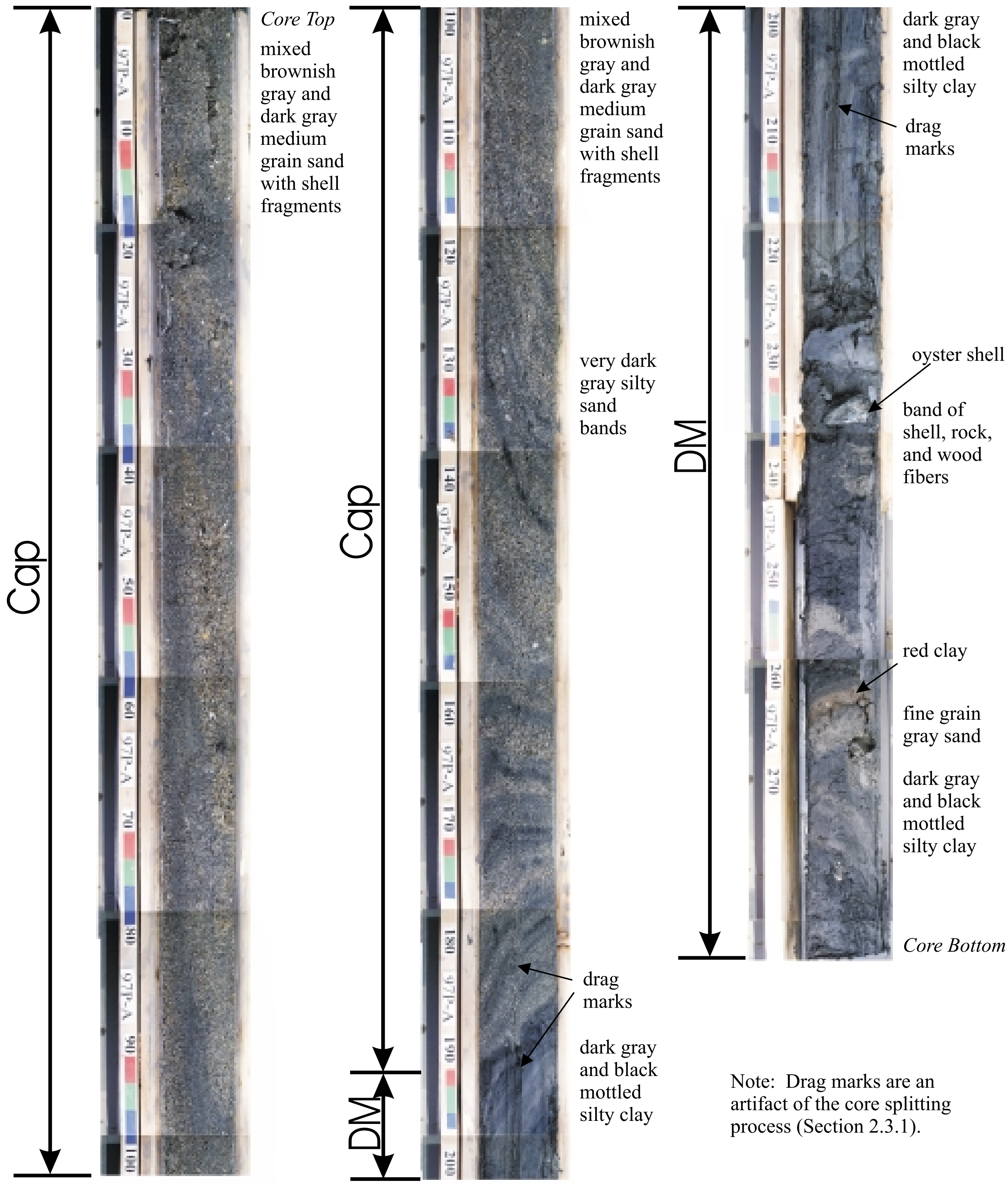
Core Top
brownish gray medium grain sand with shell fragments
Cap
brownish gray medium grain sand with shell fragments
Cap
medium grain brownish gray sand and shell fragments mottled with dark gray silty sand
brownish gray medium grain sand with shell fragments mottled with dark gray silty sand
Cap
black and dark gray mottled silty clay
DM
Core Bottom
plastic core cap

Core 97O-A



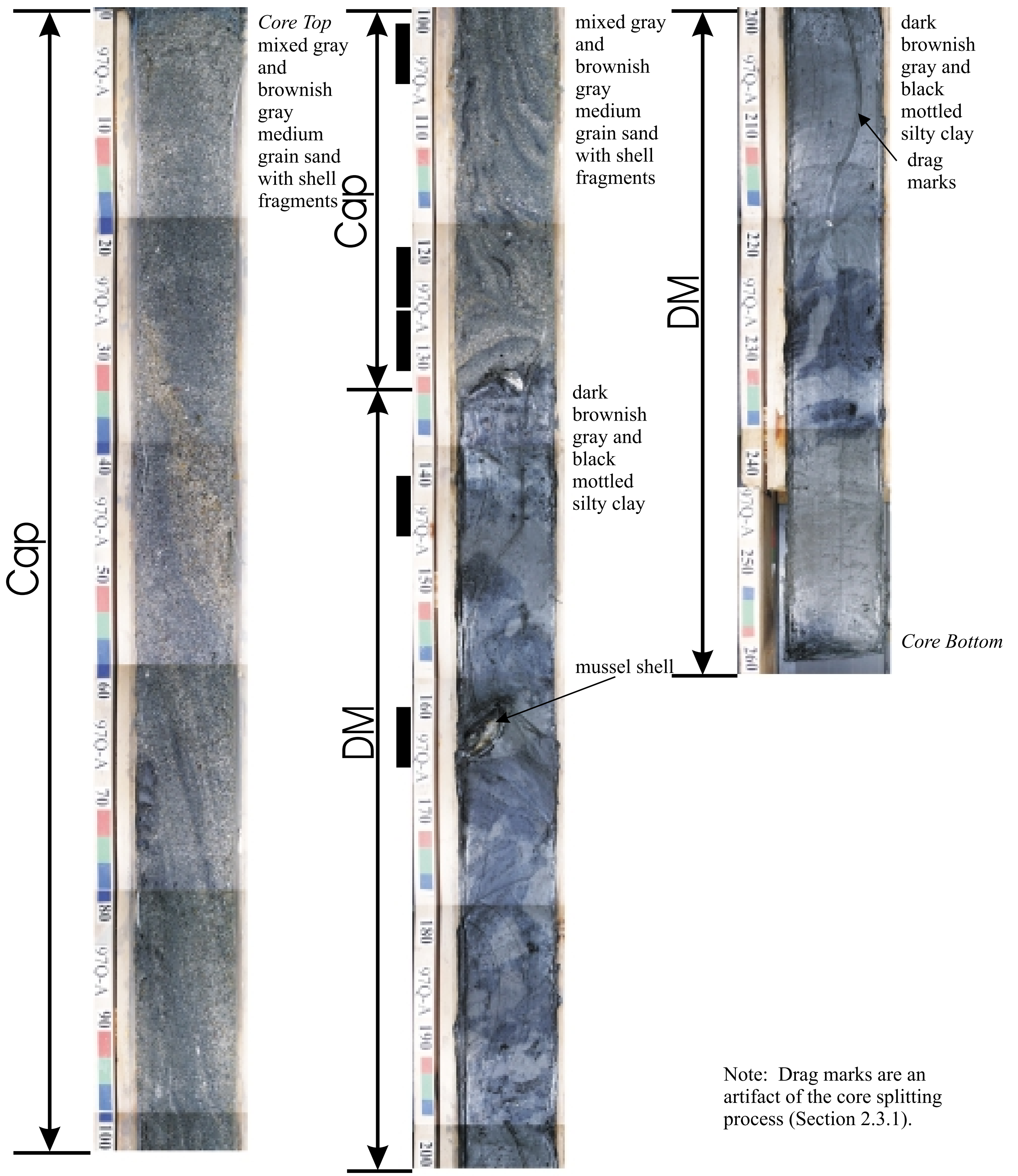
Note: Drag marks are an artifact of the core splitting process (Section 2.3.1).

Core 97P-A



Note: Drag marks are an artifact of the core splitting process (Section 2.3.1).

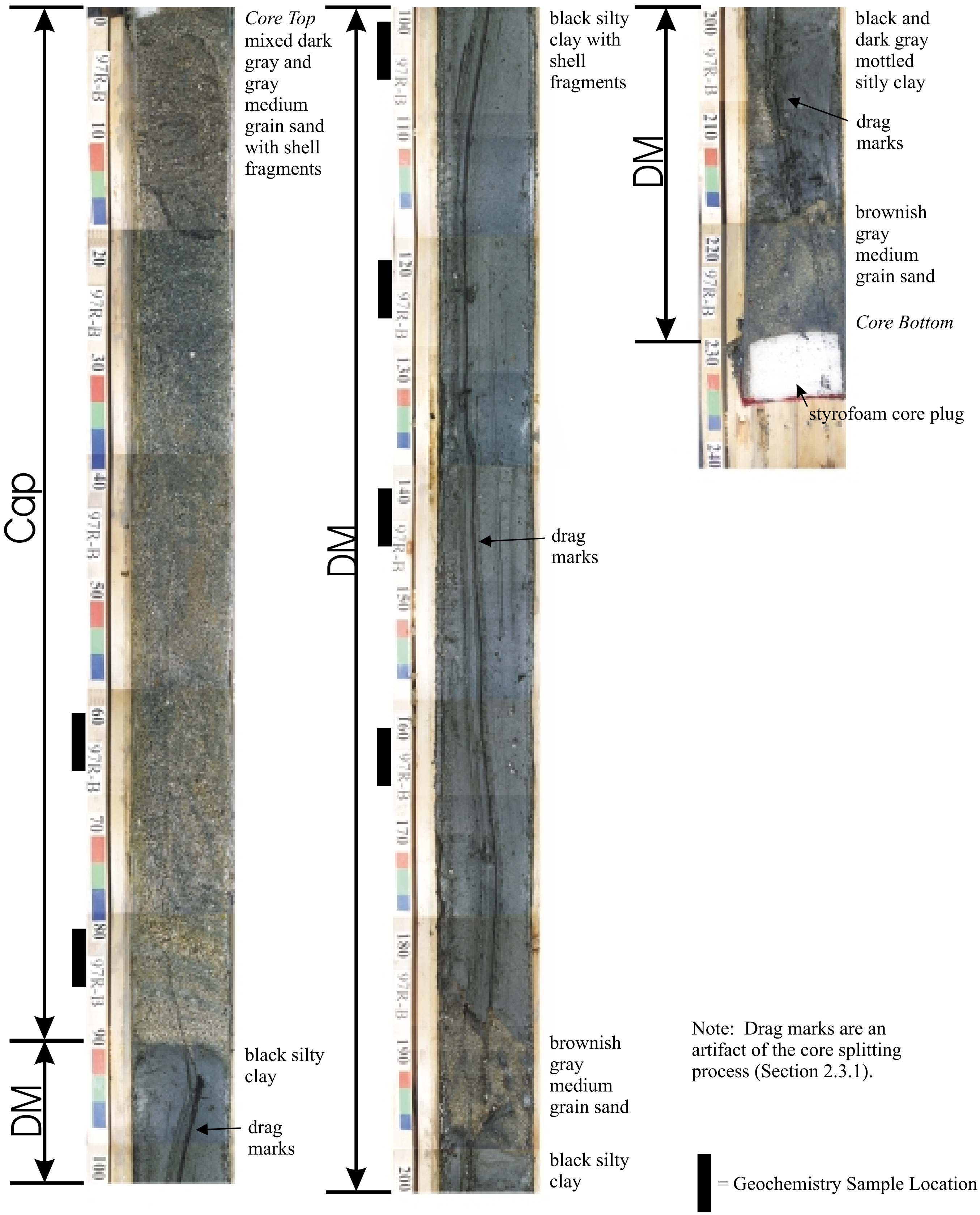
Core 97Q-A



Note: Drag marks are an artifact of the core splitting process (Section 2.3.1).

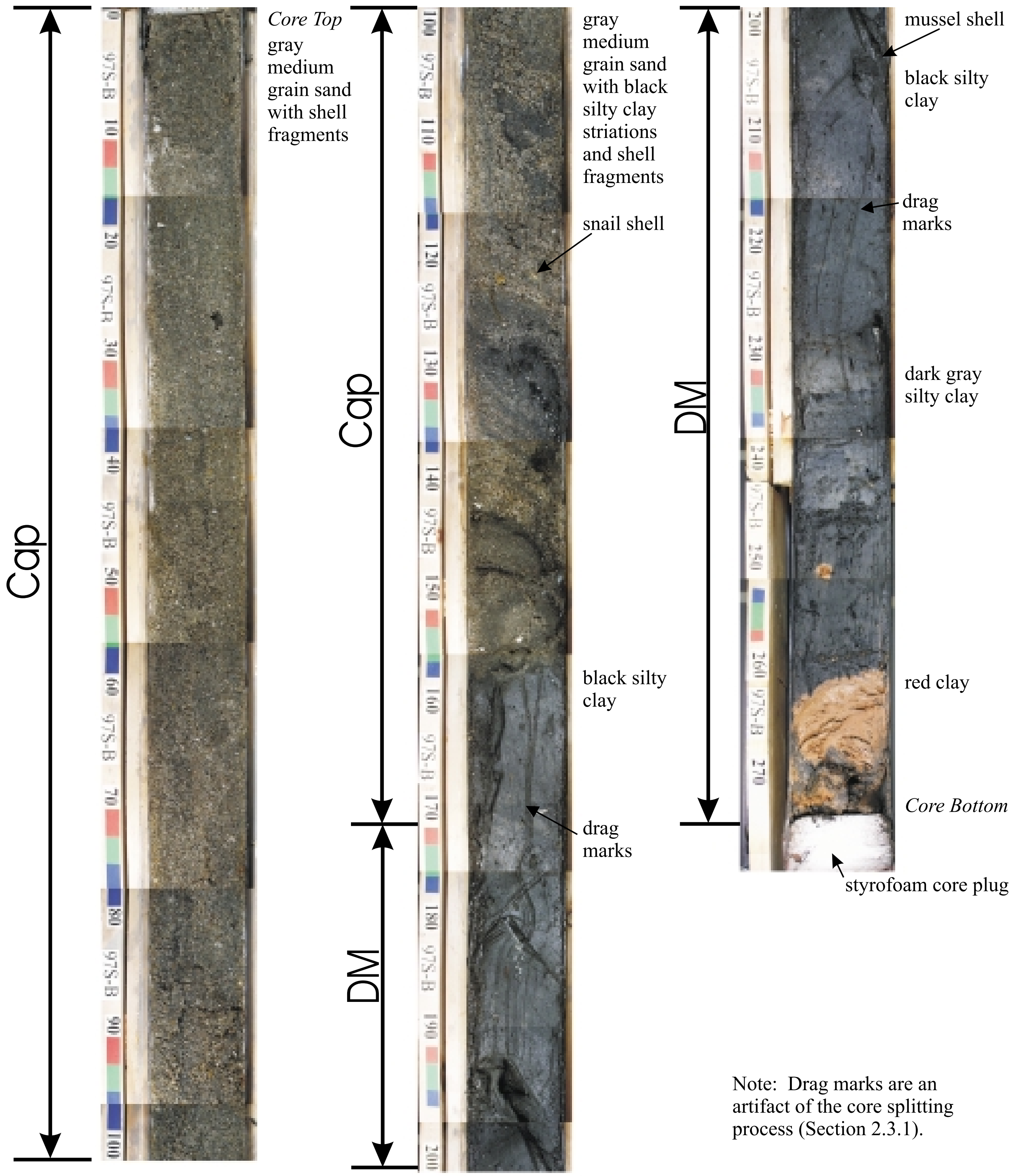
▮ = Geochemistry Sample Location

Core 97R-B



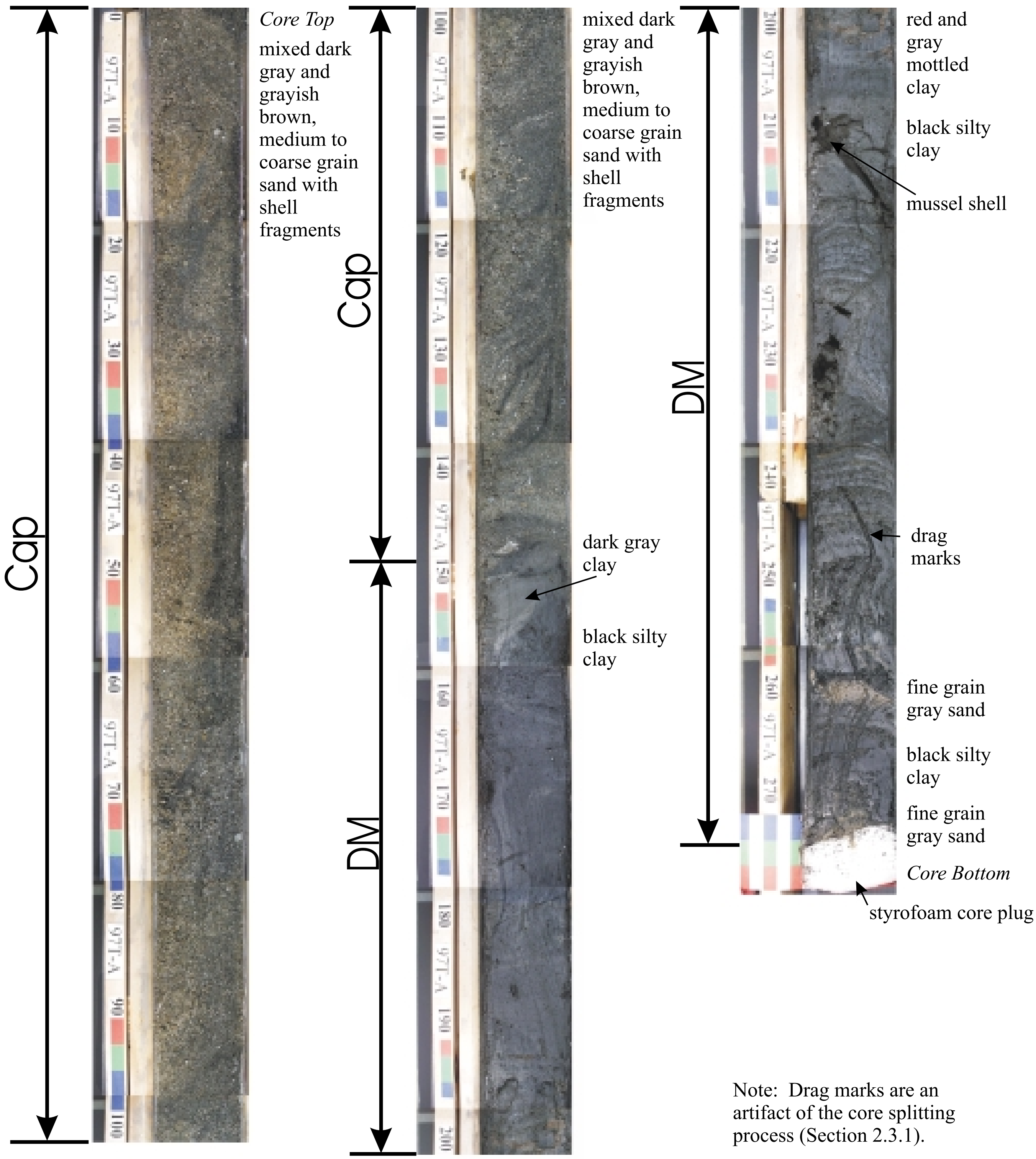
Cap
DM
Core Top
mixed dark gray and gray medium grain sand with shell fragments
black silty clay
drag marks
DM
black silty clay with shell fragments
drag marks
brownish gray medium grain sand
black silty clay
DM
black and dark gray mottled sitly clay
drag marks
brownish gray medium grain sand
Core Bottom
styrofoam core plug
Note: Drag marks are an artifact of the core splitting process (Section 2.3.1).
= Geochemistry Sample Location

Core 97S-B



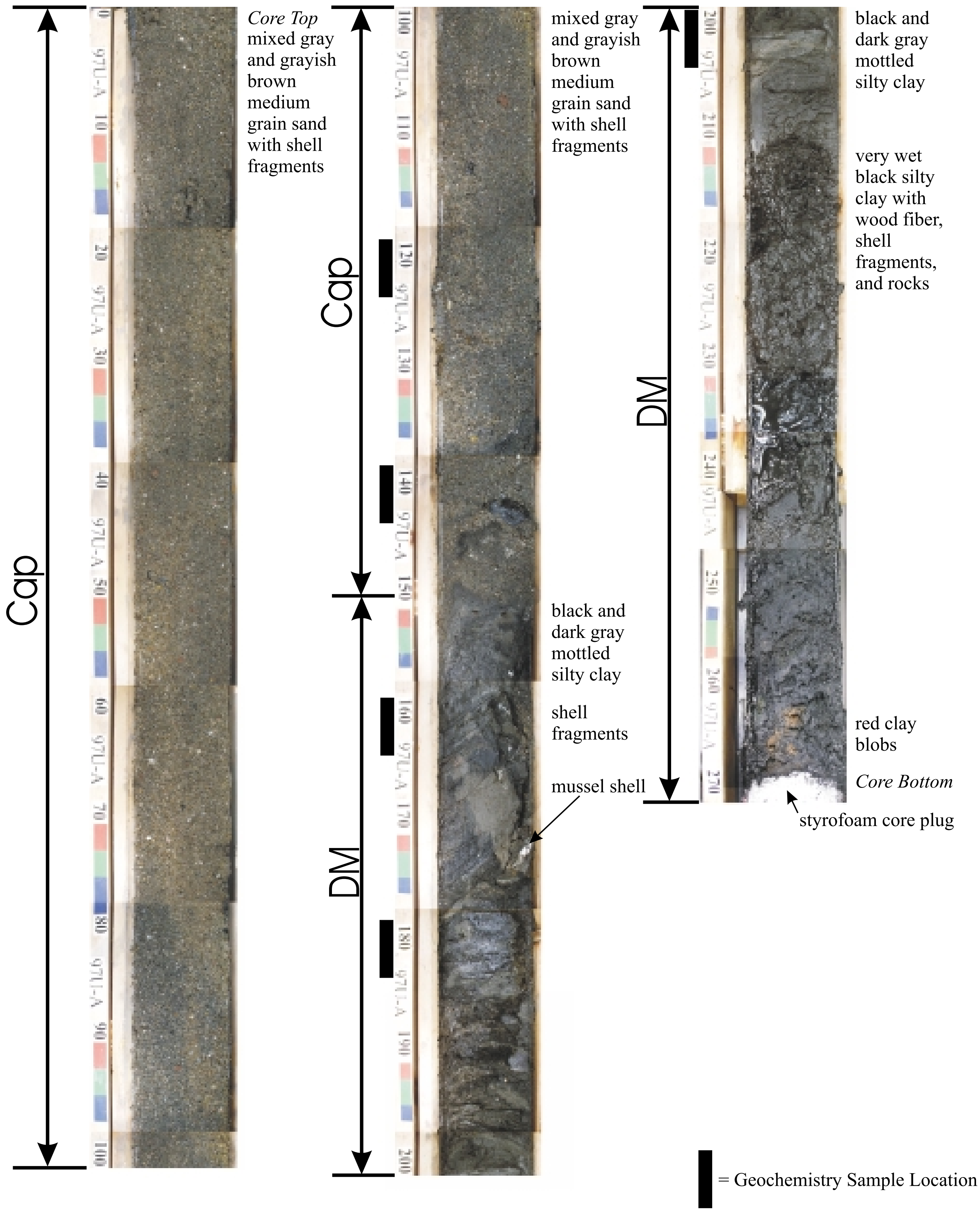
Note: Drag marks are an artifact of the core splitting process (Section 2.3.1).

Core 97T-A



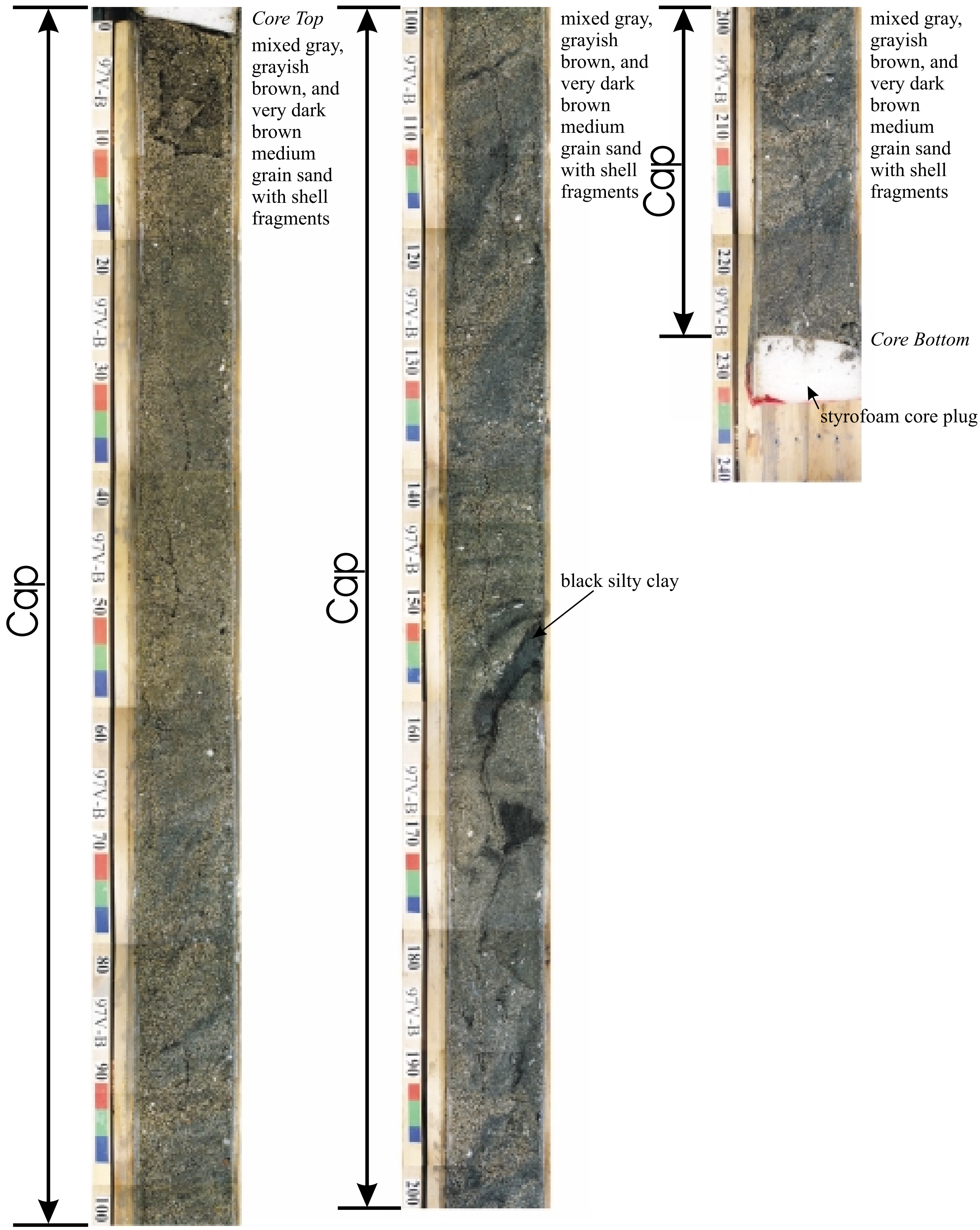
Note: Drag marks are an artifact of the core splitting process (Section 2.3.1).

Core 97U-A



Core Top
mixed gray and grayish brown medium grain sand with shell fragments
Cap
mixed gray and grayish brown medium grain sand with shell fragments
Cap
black and dark gray mottled silty clay
shell fragments
mussel shell
DM
black and dark gray mottled silty clay
very wet black silty clay with wood fiber, shell fragments, and rocks
DM
red clay blobs
Core Bottom
styrofoam core plug
= Geochemistry Sample Location

Core 97V-B


Cap
Core Top
mixed gray, grayish brown, and very dark brown medium grain sand with shell fragments
Cap
mixed gray, grayish brown, and very dark brown medium grain sand with shell fragments
black silty clay
Cap
mixed gray, grayish brown, and very dark brown medium grain sand with shell fragments
Core Bottom
styrofoam core plug

APPENDIX B
Discrete Data Geotechnical

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent				Sand Components				Void Ratio
										>Coarse (%)	Sand (%)	Silt (%)	Clay (%)	% Coarse	% Medium	% Fine	% Very Fine	
0-30	Cap	Moist, brown sand	SP	1.85	20.7	---	---	---	---	4.5	94.5	1.0		12.0	42.5	34.0	6.0	0.7
30-60	Cap	Moist, brown sand	---	1.80	16.8	---	---	---	---	---	---	---	---	---	---	---	---	0.7
60-80	Cap	Moist, brown sand	SP	1.93	19.6	---	---	---	---	4.5	94.5	1.0		20.5	49.0	22.5	2.5	0.6
80-90	Cap	Moist, brown sand with some silt	---	1.83	19.2	---	---	---	---	---	---	---	---	---	---	---	---	0.7
90-105	Cap	Moist, brown sand with some silt; silt vein	---	1.80	20.3	---	---	---	---	---	---	---	---	---	---	---	---	0.7
105-110	DM	Moist, dark brown clay with sand	---	1.56	66.9	---	---	---	---	---	---	---	---	---	---	---	---	1.79
110-120	DM	Moist, dark brown clay with sand	---	1.59	66.5	---	---	---	---	---	---	---	---	---	---	---	---	1.71
120-130	DM	Moist, dark brown clay with sand	CH	1.58	69.0	61.6	27.0	34.6	2.56	1.5	17.0	55.5	26.0	1.0	3.5	5.0	7.5	1.79
130-135	DM	Moist, dark brown clay with sand	---	1.59	65.9	---	---	---	---	---	---	---	---	---	---	---	---	1.71
135-140	DM	Moist, dark brown clay with sand; shell fragments	---	1.56	64.8	---	---	---	---	---	---	---	---	---	---	---	---	1.75
140-150	DM	Moist, dark brown clay with sand; shell fragments	---	1.60	61.9	---	---	---	---	---	---	---	---	---	---	---	---	1.64
150-160	DM	Moist, dark brown clay with sand; shell fragments	CH	1.64	54.4	62.8	27.6	35.2	---	1.5	20.5	44.0	34.0	1.0	3.5	7.0	9.0	1.45
160-175	DM	Moist, dark brown clay with sand	---	1.58	66.0	---	---	---	---	---	---	---	---	---	---	---	---	1.72
175-190	DM	Moist, dark brown clay with sand; mottled gray clay	---	1.58	67.3	---	---	---	2.59	2.0	24.0	44.0	30.0	0.5	2.5	4.5	16.5	1.75
190-200	DM	Moist, dark brown clay with sand; mottled gray clay; shells	---	1.59	64.5	---	---	---	---	---	---	---	---	---	---	---	---	1.69
200-220	DM	Moist, dark brown clay with sand; mottled gray clay; shells	---	1.55	69.3	---	---	---	---	0.5	16.5	59.0	24.0	0.5	1.0	4.0	11.0	1.83
220-230	DM	Moist, dark brown clay with sand	---	1.37	100.8	---	---	---	---	---	---	---	---	---	---	---	---	2.80
230-250	DM	Moist, dark brown clay with sand; silt vein	---	1.71	38.3	---	---	---	---	---	---	---	---	---	---	---	---	1.10
250-265	DM	Moist, dark brown clay with sand	CH	1.86	34.1	95.5	32.8	62.7	2.56	1.0	12.0	48.0	39.0	2.0	4.0	3.0	3.0	0.88
265-284	DM	Moist, dark brown clay with sand	---	1.38	108.7	---	---	---	---	---	---	---	---	---	---	---	---	2.94

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Sand Components % Coarse	% Medium	% Fine	% Very Fine	Void Ratio
0-40	Cap	Moist, brown sand	SP	1.88	19.5	---	---	---	---	2.5	96.5	1.0		17.5	48.0	28.0	3.0	0.7
	Cap	**TRIPLICATE ANALYSIS**	SP	---	19.6	---	---	---	---	2.5	96.5	1.0		17.5	49.0	27.0	3.0	0.7
	Cap	**TRIPLICATE ANALYSIS**	SP	---	19.4	---	---	---	---	2.5	96.5	1.0		17.5	48.0	28.0	3.0	0.7
40-70	Cap	Moist, brown sand	---	1.80	19.0	---	---	---	---	---	---	---	---	---	---	---	---	---
70-90	Cap	Moist, brown sand	---	1.77	18.2	---	---	---	---	---	---	---	---	---	---	---	---	---
90-110	Cap	Moist, brown sand	SP	1.90	21.2	---	---	---	---	3.0	96.0	1.0		12.0	38.0	40.0	6.0	0.7
110-140	Cap	Moist, brown sand	---	1.87	21.0	---	---	---	---	---	---	---	---	---	---	---	---	0.7
140-145	DM	Moist, dark brown clayey sand	---	1.59	62.3	---	---	---	---	---	---	---	---	---	---	---	---	1.65
145-155	DM	Moist, dark brown clayey sand	SC	1.76	43.3	49.6	24.7	24.9	---	3.0	59.5	28.5	9.0	4.5	15.5	19.0	20.5	1.12
155-165	DM	Moist, dark brown clayey sand	---	1.62	66.7	---	---	---	---	---	---	---	---	---	---	---	---	1.67
165-180	DM	Moist, dark brown clay with sand; large shell	---	1.49	90.5	---	---	---	---	23.5	14.0	40.5	22.0	1.5	3.0	2.0	7.5	2.32
180-190	DM	Moist, dark brown clay with sand	---	1.52	82.8	---	---	---	2.58	3.0	19.5	50.5	27.0	2.0	3.0	4.0	10.5	2.12
190-200	DM	Moist, dark brown clay with sand	---	1.53	85.1	---	---	---	---	---	---	---	---	---	---	---	---	2.15
200-220	DM	Moist, dark brown clay with sand; 200-210 many shells	---	1.59	70.2	---	---	---	---	---	---	---	---	---	---	---	---	1.78
220-225	DM	Moist, dark brown clay with sand	CH	1.52	78.5	81.7	33.1	48.5	2.60	1.5	17.0	58.5	23.0	1.0	2.5	2.5	11.0	2.06
225-230	DM	Moist, dark brown clay with sand	---	1.53	81.8	---	---	---	---	---	---	---	---	---	---	---	---	2.08
230-240	DM	Moist, dark brown clay with sand	---	1.70	52.1	---	---	---	---	---	---	---	---	---	---	---	---	1.32
240-245	DM	Moist, dark brown clay with sand	---	1.72	49.8	---	---	---	---	---	---	---	---	---	---	---	---	1.26
245-250	DM	Moist, dark brown clay with sand	---	1.76	47.9	---	---	---	---	---	---	---	---	---	---	---	---	1.18
250-255	DM	Moist, dark brown clay with sand	---	1.71	47.1	---	---	---	---	---	---	---	---	---	---	---	---	1.24
255-260	DM	Moist, dark brown clay with sand	---	1.66	46.5	---	---	---	---	---	---	---	---	---	---	---	---	1.30
260-270	DM	Moist, dark brown clay with sand	CH	1.53	83.6	67.0	29.7	37.3	2.56	0.0	14.5	60.5	25.0	0.5	1.5	3.0	9.5	2.10

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Sand Components % Coarse	% Medium	% Fine	% Very Fine	Void Ratio
0-20	Cap	Moist, brown sand	---	1.90	20.3	---	---	---	---	---	---	---	---	---	---	---	---	0.6
20-40	Cap	Moist, brown sand	---	1.87	19.7	---	---	---	---	---	---	---	---	---	---	---	---	0.7
40-70	Cap	Moist, brown sand	---	1.77	17.6	---	---	---	---	---	---	---	---	---	---	---	---	0.7
70-100	Cap	Moist, brown sand	---	1.81	20.3	---	---	---	---	---	---	---	---	---	---	---	---	0.7
100-120	Cap	Moist, brown sand	SP	1.80	20.7	---	---	---	---	1.0	98.0	1.0		7.0	35.0	49.0	7.0	0.7
120-135		Moist, brown sand	SP	---	---	---	---	---	---	2.0	97.0	1.0		8.5	38.5	44.5	5.5	
135-150	DM	Moist, dark brown clay with sand	---	1.63	61.0	---	---	---	---	1.5	37.0	40.5	21.0	3.5	11.0	10.5	12.0	1.58
150-160	DM	Moist, dark brown sandy clay; sand vein	---	1.59	65.9	---	---	---	---	---	---	---	---	---	---	---	---	1.71
160-175	DM	Moist, dark brown sandy clay	CH	1.72	43.6	52.8	25.0	27.8	2.63	1.5	35.5	40.0	23.0	2.5	10.0	11.5	11.5	1.17
175-185	DM	Moist, dark brown clay with sand; sand vein	---	1.74	47.3	---	---	---	2.61	1.0	31.5	42.5	25.0	2.0	9.0	10.0	10.5	1.20
185-195	DM	Moist, dark brown clay with sand	---	1.66	53.5	---	---	---	---	---	---	---	---	---	---	---	---	1.41
195-205	DM	Moist, dark brown clay with sand; sand vein	---	1.71	52.0	---	---	---	---	---	---	---	---	---	---	---	---	1.32
205-210	DM	Moist, dark brown clay with sand; sand vein	---	1.86	25.8	---	---	---	---	---	---	---	---	---	---	---	---	0.76
210-220	DM	Moist, dark brown clay with sand	---	1.70	42.8	---	---	---	---	---	---	---	---	---	---	---	---	1.18
220-225	DM	Moist, dark brown clay with sand	---	1.68	54.8	---	---	---	---	---	---	---	---	---	---	---	---	1.39
225-235	DM	Moist, dark brown clay with sand	---	1.74	36.7	---	---	---	---	---	---	---	---	---	---	---	---	1.04
235-245	DM	Moist, dark brown clay with sand	---	1.74	46.1	---	---	---	---	---	---	---	---	---	---	---	---	1.18
245-250	DM	Moist, dark brown clay with sand	---	1.70	46.1	---	---	---	---	---	---	---	---	---	---	---	---	1.23
250-255	DM	Moist, dark brown sandy clay	CL	1.76	43.9	42.0	22.5	19.5	---	1.5	37.0	40.5	21.0	3.5	10.0	10.5	13.0	1.12
	DM	**TRIPLICATE ANALYSIS**	---	---	43.6	---	---	---	---	2.0	36.5	40.5	21.0	3.0	10.0	10.5	13.0	---
	DM	**TRIPLICATE ANALYSIS**	---	---	43.7	---	---	---	---	2.0	37.5	38.5	22.0	3.0	10.0	10.5	14.0	---
255-260	DM	Moist, dark brown sandy clay	---	1.80	40.2	---	---	---	---	---	---	---	---	---	---	---	---	1.02
260-270	DM	Moist, dark brown sandy clay	CL	1.87	31.9	38.1	21.9	16.2	2.66	2.5	37.0	45.5	15.0	2.0	8.5	10.0	16.5	0.83

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Sand Components % Coarse	% Medium	% Fine	% Very Fine	Void Ratio
0-30	Cap	Moist, brown sand	---	1.79	19.6	---	---	---	---	---	---	---	---	---	---	---	---	0.7
30-60	Cap	Moist, brown sand	SP	1.82	20.4	---	---	---	---	2.0	97.0	1.0		22.5	50.5	21.5	2.5	0.7
60-80	Cap	Moist, brown sand	---	1.87	19.2	---	---	---	---	---	---	---	---	---	---	---	---	0.7
80-100	Cap	Moist, brown sand	SP	1.92	18.4	---	---	---	---	3.5	94.5	2.0		21.0	49.5	22.0	2.0	0.6
100-125	Cap	Moist, brown sand	---	1.79	19.7	---	---	---	---	---	---	---	---	---	---	---	---	0.7
125-135	DM	Moist, dark brown clay with sand	---	1.63	59.8	---	---	---	---	---	---	---	---	---	---	---	---	1.55
135-145	DM	Moist, dark brown clay with sand	CH	1.62	59.8	58.9	26.6	32.3	2.55	1.5	25.5	48.0	25.0	1.0	6.5	7.0	11.0	1.56
145-155	DM	Moist, dark brown clay with sand	---	1.66	55.5	---	---	---	---	---	---	---	---	---	---	---	---	1.43
155-165	DM	Moist, dark brown clay with sand	---	1.64	57.5	---	---	---	---	---	---	---	---	---	---	---	---	1.50
165-175	DM	Moist, dark brown clay with sand	CH	1.62	57.7	60.0	27.7	32.3	---	1.5	22.0	45.5	31.0	1.0	6.5	6.0	8.5	1.53
175-185	DM	Moist, dark brown clay with sand	---	1.64	61.3	---	---	---	---	---	---	---	---	---	---	---	---	1.55
185-195	DM	Moist, dark brown clay with sand; large shell	---	1.59	61.8	---	---	---	---	---	---	---	---	---	---	---	---	1.64
195-205	DM	Moist, dark brown clay with sand	---	1.59	58.4	---	---	---	---	---	---	---	---	---	---	---	---	1.59
205-215	DM	Moist, dark brown clay with sand; large shell	---	1.67	54.9	---	---	---	2.57	1.0	19.5	50.5	29.0	1.0	3.0	5.0	10.5	1.42
215-230	DM	Moist, dark brown clay with sand; shells	---	1.65	55.1	---	---	---	---	---	---	---	---	---	---	---	---	1.45
230-245	DM	Moist, dark brown clay with sand; shells	---	1.50	84.3	---	---	---	---	1.0	13.5	68.5	17.0	1.0	2.0	4.5	6.0	2.19
245-255	DM	Moist, dark brown clay with sand	---	1.57	72.8	---	---	---	---	---	---	---	---	---	---	---	---	1.87
255-260	DM	Moist, dark brown clay with sand	---	1.66	54.5	---	---	---	---	---	---	---	---	---	---	---	---	1.42
260-270	DM	Moist, dark brown clay with sand	---	1.60	65.6	---	---	---	---	---	---	---	---	---	---	---	---	1.70
270-280	DM	Moist, dark brown clay with sand	CH	1.63	55.5	63.1	25.3	37.8	2.59	1.0	21.0	48.0	30.0	1.0	7.0	7.0	6.0	1.49

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent				Sand Components				Void Ratio
										>Coarse (%)	Sand (%)	Silt (%)	Clay (%)	% Coarse	% Medium	% Fine	% Very Fine	
0-30	Cap	Moist, brown sand	---	1.87	20.4	---	---	---	---	---	---	---	---	---	---	---	---	0.7
30-60	Cap	Moist, brown sand	---	1.85	20.1	---	---	---	---	---	---	---	---	---	---	---	---	0.7
60-90	Cap	Moist, brown sand	---	1.89	21.4	---	---	---	---	---	---	---	---	---	---	---	---	0.7
90-120	Cap	Moist, brown sand	---	1.77	18.9	---	---	---	---	---	---	---	---	---	---	---	---	0.7
120-150	Cap	Moist, brown sand	SP	1.87	21.7	---	---	---	---	3.5	95.5	1.0		9.0	35.5	42.0	9.0	0.7
150-160	DM	Moist, brown sand	SP	---	---	---	---	---	---	3.0	96.0	1.0		10.0	37.0	40.0	9.0	---
160-167	DM	Mottled moist, brown sand and moist, dark brown clay with sand	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
167-175	DM	Moist, dark brown clay with sand	---	1.61	62.7	---	---	---	---	---	---	---	---	---	---	---	---	1.62
175-185	DM	Moist, dark brown clay with sand	---	1.70	49.1	---	---	---	2.62	0.0	30.0	50.0	20.0	2.0	7.0	9.0	12.0	1.28
185-195	DM	Moist, dark brown clay with sand	CH	1.58	71.3	68.2	28.7	39.5	---	1.0	18.5	56.5	24.0	0.5	3.5	4.0	10.5	1.83
195-205	DM	Moist, dark brown clay with sand	---	1.56	73.4	---	---	---	2.61	0.0	16.0	53.0	31.0	1.5	2.5	3.0	9.0	1.89
205-210	DM	Moist, dark brown clay with sand	---	1.57	69.2	---	---	---	---	---	---	---	---	---	---	---	---	1.80
210-215	DM	Moist, dark brown clay with sand	CH	1.57	69.5	75.2	30.6	44.6	---	1.0	14.0	57.0	28.0	1.0	3.0	2.0	8.0	1.81
215-220	DM	Moist, dark brown clay with sand	---	1.58	69.8	---	---	---	---	---	---	---	---	---	---	---	---	1.79
220-225	DM	Moist, dark brown clay with sand	---	1.59	69.1	---	---	---	---	---	---	---	---	---	---	---	---	1.77
225-230	DM	Moist, dark brown clay with sand	---	1.57	71.5	---	---	---	---	---	---	---	---	---	---	---	---	1.84
230-235	DM	Moist, dark brown clay with sand	---	1.58	69.2	---	---	---	---	---	---	---	---	---	---	---	---	1.78
235-240	DM	Moist, dark brown clay with sand	---	1.55	73.1	---	---	---	---	---	---	---	---	---	---	---	---	1.90
240-245	DM	Moist, dark brown clay with sand	---	1.55	71.8	---	---	---	---	---	---	---	---	---	---	---	---	1.88
245-250	DM	Moist, dark brown clay with sand	CH	1.56	68.8	72.1	28.5	43.6	2.59	0.5	18.5	53.0	28.0	1.5	3.0	2.5	11.5	1.81
250-255	DM	Moist, dark brown clay with sand	---	1.59	65.4	---	---	---	---	---	---	---	---	---	---	---	---	1.70

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent				Sand Components				Void Ratio
										>Coarse (%)	Sand (%)	Silt (%)	Clay (%)	% Coarse	% Medium	% Fine	% Very Fine	
0-30	Cap	Moist, brown sand	SP	1.89	19.4	---	---	---	---	2.5	96.5	1.0		30.5	55.0	10.0	1.0	0.6
30-60	Cap	Moist, brown sand	---	1.90	20.3	---	---	---	---	---	---	---	---	---	---	---	---	0.6
60-120	Cap	Moist, brown sand	---	1.79	20.1	---	---	---	---	---	---	---	---	---	---	---	---	0.7
120-180	Cap	Moist, brown sand	SP	1.88	21.0	---	---	---	---	1.5	97.5	1.0		11.5	47.0	33.0	6.0	0.7
180-221	Cap	Moist, brown sand	---	1.85	29.3	---	---	---	---	---	---	---	---	---	---	---	---	0.8
221-225	DM	Moist, dark brown clay with sand	CH	1.58	59.2	64.4	28.7	35.7	2.57	1.0	21.0	55.0	23.0	1.0	3.0	5.0	12.0	1.62
225-230	DM	Moist, dark brown clay with sand	CH	1.68	57.9	66.0	28.3	37.7	2.63	1.0	22.0	52.0	25.0	1.0	6.0	7.0	8.0	1.45
230-235	DM	Moist, dark brown clay with sand	---	1.68	59.5	---	---	---	2.60	2.0	23.0	47.0	28.0	1.5	4.5	5.5	11.5	1.47
235-240	DM	Moist, dark brown clay with sand	---	1.68	53.4	---	---	---	---	0.5	28.0	47.5	24.0	2.0	6.5	8.5	11.0	1.38
240-245	DM	Moist, dark brown clay with sand	CH	1.74	48.3	57.0	26.1	30.9	---	0.5	28.0	46.5	25.0	2.0	7.5	8.5	10.0	1.22
245-250	DM	Moist, dark brown clay with sand	---	1.71	52.2	---	---	---	---	---	---	---	---	---	---	---	---	1.31
250-259	DM	Moist, dark brown clay with sand	---	1.72	40.1	---	---	---	---	---	---	---	---	---	---	---	---	1.11

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent				Sand Components				Void Ratio
										>Coarse (%)	Sand (%)	Silt (%)	Clay (%)	% Coarse	% Medium	% Fine	% Very Fine	
0-40	Cap	Moist, brown sand	---	1.89	20.6	---	---	---	---	---	---	---	---	---	---	---	---	0.7
40-80	Cap	Moist, brown sand; gray silt vein	SP	1.83	21.3	---	---	---	---	0.5	98.5	1.0		20.0	55.5	21.5	1.5	0.7
80-120	Cap	Moist, brown sand; gray silt vein	---	1.75	16.4	---	---	---	---	---	---	---	---	---	---	---	---	0.7
120-130	Cap	Moist, brown sand; gray silt vein	SP	1.86	21.2	---	---	---	---	2.0	97.0	1.0		18.0	50.0	26.5	2.5	0.7
130-148	Cap	Moist, brown sand	---	1.77	15.7	---	---	---	---	---	---	---	---	---	---	---	---	0.7
148-155	DM	Moist, dark brown sandy clay	---	1.72	46.5	---	---	---	---	---	---	---	---	---	---	---	---	1.21
155-165	DM	Moist, dark brown sandy clay	CL	1.68	54.7	49.9	25.0	24.9	2.63	0.0	36.0	36.0	28.0	2.5	9.5	10.5	13.5	1.40
165-170	DM	Moist, dark brown sandy clay	---	1.58	70.8	---	---	---	---	---	---	---	---	---	---	---	---	1.81
170-180	DM	Moist, dark brown sandy clay	---	1.53	75.8	---	---	---	---	---	---	---	---	---	---	---	---	1.99
180-190	DM	Moist, dark brown clay with sand; shells	---	1.60	65.6	---	---	---	---	1.5	20.5	51.0	27.0	1.5	7.0	4.5	7.5	1.69
190-200	DM	Moist, dark brown clay with sand	---	1.43	96.5	---	---	---	---	---	---	---	---	---	---	---	---	2.58
200-205	DM	Moist, dark brown sandy clay	CH	1.65	53.1	53.8	23.8	30.0	2.61	1.0	32.0	42.0	25.0	1.0	10.0	10.0	11.0	1.42
205-215	DM	Moist, dark brown sandy clay	---	1.66	54.2	---	---	---	---	---	---	---	---	---	---	---	---	1.41
215-220	DM	Moist, dark brown clay with sand	---	1.59	63.5	---	---	---	---	---	---	---	---	---	---	---	---	1.67
220-230	DM	Moist, dark brown clay with sand; large shell	---	1.54	73.6	---	---	---	---	---	---	---	---	---	---	---	---	1.94
230-235	DM	Moist, dark brown clay with sand	CH	1.54	72.6	72.1	29.7	42.4	2.63	1.0	14.0	57.0	28.0	1.0	3.0	2.5	7.5	1.91
235-245	DM	Moist, dark brown clay with sand	---	1.55	73.3	---	---	---	---	---	---	---	---	---	---	---	---	1.90
245-255	DM	Moist, dark brown clay with sand	---	1.54	75.0	---	---	---	---	---	---	---	---	---	---	---	---	1.95
255-265	DM	Moist, dark brown clay with sand	---	1.62	58.9	---	---	---	---	---	---	---	---	---	---	---	---	1.54
265-272	DM	Moist, dark brown clay with sand	---	1.69	49.1	---	---	---	---	6.0	20.5	47.5	26.0	1.5	5.5	4.5	9.0	1.30

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Sand Components % Coarse	% Medium	% Fine	% Very Fine	Void Ratio
0-40	Cap	Moist, brown sand	SP	1.87	20.6	---	---	---	---	1.0	95.5	3.5		16.5	44.0	31.0	4.0	0.7
40-80	Cap	Moist, brown sand	---	1.82	19.4	---	---	---	---	---	---	---	---	---	---	---	---	0.7
80-120	Cap	Moist, brown sand	---	1.89	22.1	---	---	---	---	---	---	---	---	---	---	---	---	0.7
120-160	Cap	Moist, brown sand	SP	1.82	18.4	---	---	---	---	3.0	96.0	1.0		20.5	46.5	25.5	3.5	0.7
160-190	Cap	Moist, brown sand	---	1.80	21.1	---	---	---	---	---	---	---	---	---	---	---	---	0.7
190-195	DM	Moist, dark brown clay with sand	---	1.60	66.2	---	---	---	---	---	---	---	---	---	---	---	---	1.70
195-205	DM	Moist, dark brown clay with sand	CH	1.62	62.7	73.6	30.5	43.1	2.55	0.0	12.0	54.0	34.0	1.5	2.5	4.0	4.0	1.61
205-210	DM	Moist, dark brown clay with sand	---	1.53	74.8	---	---	---	---	---	---	---	---	---	---	---	---	1.96
210-215	DM	Moist, dark brown clay with sand	---	1.54	76.8	---	---	---	---	---	---	---	---	---	---	---	---	1.99
215-220	DM	Moist, dark brown clay with sand	---	1.51	74.5	---	---	---	---	---	---	---	---	---	---	---	---	2.00
220-230	DM	Moist, dark brown clay with sand	---	1.58	65.5	---	---	---	---	1.0	19.0	55.0	25.0	1.0	4.0	3.5	10.5	1.72
230-235	DM	Moist, dark brown clay with sand	---	1.57	66.0	---	---	---	---	---	---	---	---	---	---	---	---	1.75
235-240	DM	Moist, dark brown clay with sand	CH	1.61	61.1	65.9	28.8	37.1	2.57	2.0	16.5	47.5	34.0	1.5	4.5	2.0	8.5	1.61
240-250	DM	Moist, dark brown clay with sand	---	1.60	61.5	---	---	---	---	---	---	---	---	---	---	---	---	1.63
250-255	DM	Moist, dark brown clay with sand	---	1.58	66.9	---	---	---	---	---	---	---	---	---	---	---	---	1.74
255-262	DM	Moist, dark brown clay with sand	---	1.74	44.3	---	---	---	---	2.0	27.0	45.0	26.0	4.5	8.5	5.5	8.5	1.16
262-268	DM	Moist, gray silt	---	1.97	19.7	---	---	---	---	---	---	---	---	---	---	---	---	0.58
268-275	DM	Moist, dark brown clay with sand	---	1.67	54.7	---	---	---	---	---	---	---	---	---	---	---	---	1.41
275-284	DM	Moist, dark brown clay with sand	CH	1.53	58.0	63.4	27.9	35.5	2.57	0.5	12.0	57.5	30.0	0.5	2.0	2.0	7.5	1.68

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent				Sand Components				Void Ratio
										>Coarse (%)	Sand (%)	Silt (%)	Clay (%)	% Coarse	% Medium	% Fine	% Very Fine	
0-30	Cap	Moist, brown sand	---	1.90	21.3	---	---	---	---	---	---	---	---	---	---	---	---	0.7
30-60	Cap	Moist, brown sand	---	1.88	19.0	---	---	---	---	---	---	---	---	---	---	---	---	0.6
60-90	Cap	Moist, brown sand	---	1.83	19.4	---	---	---	---	---	---	---	---	---	---	---	---	0.7
90-110	Cap	Moist, brown sand	SP	1.86	22.5	---	---	---	---	2.0	97.0	1.0		7.5	35.5	47.5	6.5	0.7
110-132	Cap	Moist, brown sand	SP	1.91	21.9	---	---	---	---	2.5	96.5	1.0		8.0	35.5	46.5	6.5	0.7
132-145	DM	Moist, dark brown clay with sand	CH	1.57	66.5	76.0	31.2	44.8	2.60	2.0	19.5	50.5	28.0	1.0	7.0	6.5	5.0	1.76
145-155	DM	Moist, dark brown clay with sand	---	1.56	72.1	---	---	---	---	---	---	---	---	---	---	---	---	1.87
155-165	DM	Moist, dark brown clay with sand	---	1.55	75.5	---	---	---	---	0.5	15.0	52.5	32.0	1.5	5.0	4.0	4.5	1.95
165-175	DM	Moist, dark brown clay with sand	---	1.52	78.3	---	---	---	---	---	---	---	---	---	---	---	---	2.06
175-180	DM	Moist, dark brown clay with sand	---	1.52	78.1	---	---	---	---	---	---	---	---	---	---	---	---	2.05
180-185	DM	Moist, dark brown clay with sand	---	1.47	86.5	---	---	---	---	0.0	11.0	56.0	33.0	1.0	3.0	1.5	5.5	2.30
185-190	DM	Moist, dark brown clay with sand	---	1.53	78.7	---	---	---	---	---	---	---	---	---	---	---	---	2.04
190-195	DM	Moist, dark brown clay with sand	CH	1.52	77.1	77.5	31.5	46.0	2.61	1.0	11.5	54.5	33.0	1.0	2.0	2.0	6.5	2.03
195-205	DM	Moist, dark brown clay with sand	---	1.47	92.7	---	---	---	---	---	---	---	---	---	---	---	---	2.40
205-215	DM	Moist, dark brown clay with sand	---	1.50	83.8	---	---	---	---	---	---	---	---	---	---	---	---	2.18
215-225	DM	Moist, dark brown clay with sand	---	1.53	76.4	---	---	---	---	---	---	---	---	---	---	---	---	1.99
225-235	DM	Moist, dark brown clay with sand	---	1.53	73.4	---	---	---	---	---	---	---	---	---	---	---	---	1.94
235-245	DM	Moist, dark brown clay with sand	---	1.54	76.4	---	---	---	---	---	---	---	---	---	---	---	---	1.98
245-250	DM	Moist, dark brown clay with sand	---	1.54	72.8	---	---	---	---	---	---	---	---	---	---	---	---	1.91
250-259	DM	Moist, dark brown clay with sand	CH	1.59	65.4	80.5	34.3	46.2	2.59	0.0	10.0	59.0	31.0	0.5	0.5	1.5	7.5	1.71

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Sand Components % Coarse	% Medium	% Fine	% Very Fine	Void Ratio
0-15	Cap	Moist, brown sand	---	1.83	18.8	---	---	---	---	---	---	---	---	---	---	---	---	0.7
15-25	Cap	Moist, brown sand	---	1.87	20.5	---	---	---	---	---	---	---	---	---	---	---	---	0.7
25-40	Cap	Moist, brown sand	---	1.89	20.4	---	---	---	---	---	---	---	---	---	---	---	---	0.7
40-65	Cap	Moist, brown sand	SP	1.79	20.1	---	---	---	---	2.0	97.0	1.0		4.0	61.0	28.5	3.5	0.7
65-90	Cap	Moist, brown sand	SP	1.79	18.0	---	---	---	---	5.0	94.0	1.0		20.0	48.0	22.5	3.5	0.7
90-100	DM	Moist, dark brown clay with sand	---	1.64	59.5	---	---	---	---	---	---	---	---	---	---	---	---	1.54
100-110	DM	Moist, dark brown clay with sand	CH	1.66	57.0	58.4	26.8	31.6	2.59	1.5	22.5	48.0	28.0	1.0	4.5	5.5	11.5	1.46
110-120	DM	Moist, dark brown clay with sand	---	1.68	58.3	---	---	---	---	---	---	---	---	---	---	---	---	1.45
120-130	DM	Moist, dark brown clay with sand	---	1.64	61.2	---	---	---	---	1.0	21.5	49.5	28.0	1.0	4.0	5.0	11.5	1.55
130-140	DM	Moist, dark brown clay with sand	---	1.58	68.5	---	---	---	---	---	---	---	---	---	---	---	---	1.78
140-150	DM	Moist, dark brown clay with sand	CH	1.63	60.1	58.1	27.4	30.8	2.61	1.0	24.0	48.0	27.0	1.0	6.0	-2.0	19.0	1.55
150-160	DM	Moist, dark brown clay with sand	---	1.63	58.1	---	---	---	---	---	---	---	---	---	---	---	---	1.52
160-170	DM	Moist, dark brown clay with sand	---	1.67	54.4	---	---	---	---	1.0	21.5	50.5	27.0	1.0	5.0	5.5	10.0	1.40
170-175	DM	Moist, dark brown clay with sand	---	1.65	55.8	---	---	---	---	---	---	---	---	---	---	---	---	1.46
175-180	DM	Moist, dark brown clay with sand	---	1.64	57.1	---	---	---	---	---	---	---	---	---	---	---	---	1.49
180-185	DM	Moist, dark brown clay with sand	---	1.63	59.8	---	---	---	---	---	---	---	---	---	---	---	---	1.55
185-195	DM	Moist, dark brown clay with sand; brown sand vein	---	1.63	59.3	---	---	---	---	---	---	---	---	---	---	---	---	1.55
195-205	DM	Moist, dark brown clay with sand	---	1.57	71.5	---	---	---	---	---	---	---	---	---	---	---	---	1.85
205-210	DM	Moist, dark brown clay with sand	CH	1.61	72.5	60.2	26.3	34.0	2.63	0.5	24.5	49.0	26.0	1.0	6.5	7.5	9.5	1.79
210-214	DM	Moist, dark brown clay with sand	---	1.55	74.3	---	---	---	---	---	---	---	---	---	---	---	---	1.92
214-217	DM	Moist, dark brown clay with sand	---	1.49	65.8	---	---	---	---	---	---	---	---	---	---	---	---	1.89
217-229	DM	Moist, brown sand with silt	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Percent Sand (%)	Percent Silt (%)	Percent Clay (%)	Sand Components % Coarse	Sand Components % Medium	Sand Components % Fine	Sand Components % Very Fine	Void Ratio
0-40	Cap	Moist, brown sand	SP	1.71	20.8	---	---	---	---	3.0	96.0	1.0		4.0	59.0	30.0	3.0	0.8
40-80	Cap	Moist, brown sand	---	1.77	21.1	---	---	---	---	---	---	---	---	---	---	---	---	0.8
80-105	Cap	Moist, brown sand	SP	1.67	15.5	---	---	---	---	9.5	90.0	0.5		24.0	48.5	15.5	2.0	0.8
105-130	Cap	Mottled brown sand with dark brown silt; large shell @ 123	---	1.86	31.2	---	---	---	---	---	---	---	---	---	---	---	---	0.8
130-160	Cap	Mottled brown sand with dark brown silt	---	1.73	20.9	---	---	---	---	---	---	---	---	---	---	---	---	0.8
160-165	DM	Moist, dark brown clay with sand	---	1.62	66.5	---	---	---	---	1.5	23.5	51.0	24.0	2.0	5.5	4.5	11.5	1.67
165-175	DM	Moist, dark brown clay with sand	---	1.62	68.2	---	---	---	---	---	---	---	---	---	---	---	---	1.71
175-185	DM	Moist, dark brown clay with sand	---	1.65	62.2	---	---	---	---	1.5	25.5	50.0	23.0	1.5	6.0	4.0	14.0	1.55
185-195	DM	Moist, dark brown clay with sand	---	1.65	63.7	---	---	---	---	---	---	---	---	---	---	---	---	1.58
195-205	DM	Moist, dark brown clay with sand	CH	1.66	60.7	60.2	25.8	34.4	2.60	1.5	26.0	48.5	24.0	2.0	6.5	5.0	12.5	1.52
205-215	DM	Moist, dark brown clay with sand	---	1.67	57.0	---	---	---	---	---	---	---	---	---	---	---	---	1.45
215-225	DM	Moist, dark brown clay with sand	---	1.66	60.1	---	---	---	---	---	---	---	---	---	---	---	---	1.51
225-230	DM	Moist, dark brown clay with sand	CH	1.70	52.3	55.6	28.7	26.9	2.59	0.5	31.0	48.5	20.0	1.5	7.0	9.0	13.5	1.33
230-240	DM	Moist, dark brown clay with sand	---	1.67	56.8	---	---	---	---	---	---	---	---	---	---	---	---	1.45
240-250	DM	Moist, dark brown clay with sand	CL	1.67	58.4	47.9	23.5	24.4	2.60	1.0	29.0	52.0	18.0	1.0	5.0	9.0	14.0	1.47
250-255	DM	Moist, dark brown clay with sand	---	1.46	100.8	---	---	---	---	---	---	---	---	---	---	---	---	2.58
255-265	DM	Moist, dark brown clay with sand	---	1.36	113.6	---	---	---	---	---	---	---	---	---	---	---	---	3.09
265-270	DM	Moist, reddish brown clay	---	1.92	31.4	---	---	---	---	---	---	---	---	---	---	---	---	0.78
270-274	DM	Moist, dark brown clay with sand	---	---	---	---	---	---	---		---	---	---	---	---	---	---	---

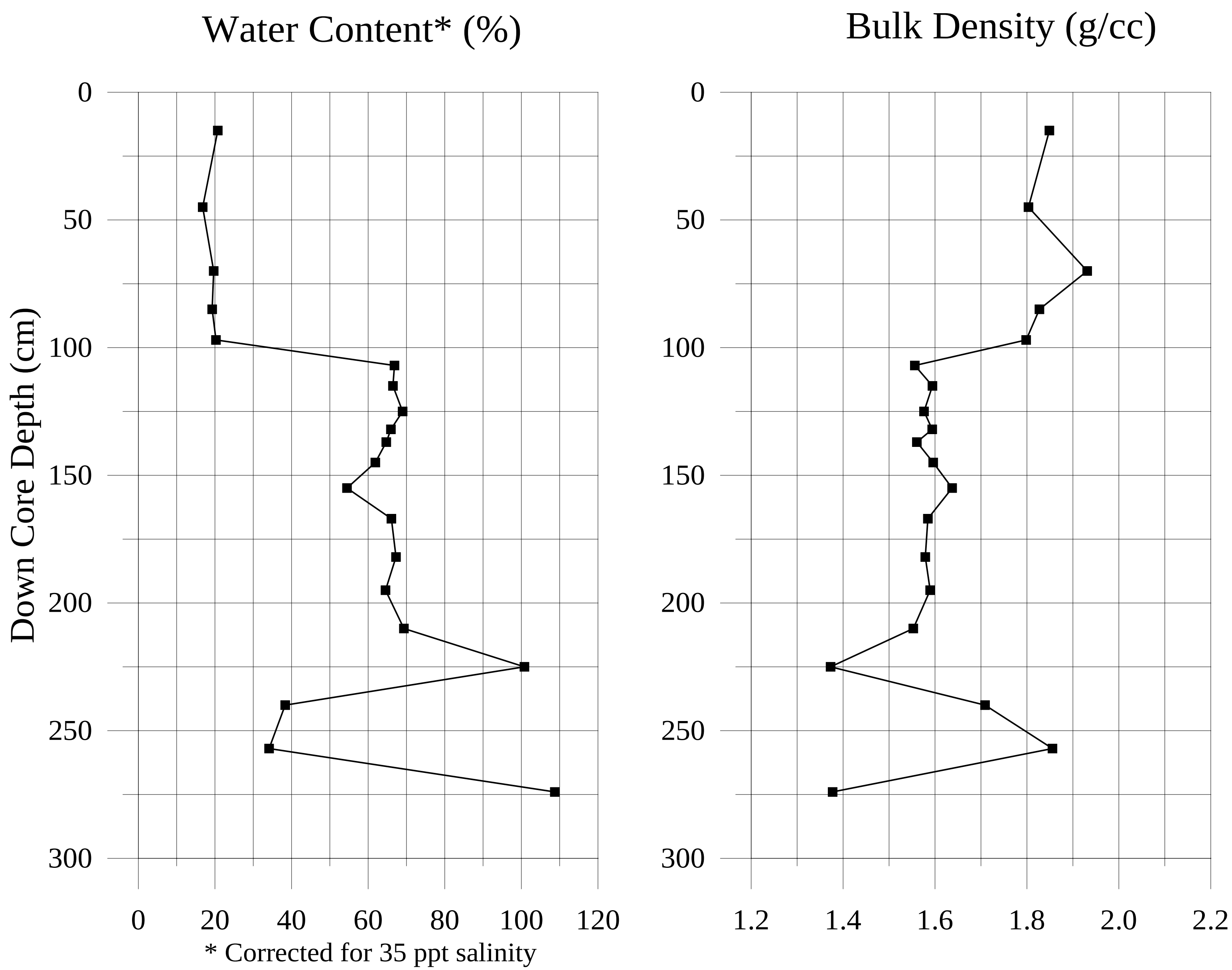
Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Percent Sand (%)	Percent Silt (%)	Percent Clay (%)	Sand Components % Coarse	Sand Components % Medium	Sand Components % Fine	Sand Components % Very Fine	Void Ratio
0-15	Cap	Moist, brown sand	---	1.95	20.6	---	---	---	---	---	---	---	---	---	---	---	---	0.6
15-30	Cap	Moist, brown sand	SP	1.90	19.7	---	---	---	---	3.5	95.5	1.0		16.5	48.0	29.0	2.0	0.6
30-70	Cap	Moist, brown sand	---	1.79	19.8	---	---	---	---	---	---	---	---	---	---	---	---	0.7
70-110	Cap	Moist, brown sand	---	1.84	19.8	---	---	---	---	---	---	---	---	---	---	---	---	0.7
110-150	Cap	Moist, brown sand	SP	1.87	22.3	---	---	---	---	1.0	98.0	1.0		6.0	32.0	51.0	9.0	0.7
150-160	DM	Moist, dark brown clay with sand	---	1.66	58.0	---	---	---	---	---	---	---	---	---	---	---	---	1.48
160-165	DM	Moist, dark brown clay with sand	---	1.60	68.6	---	---	---	---	---	---	---	---	---	---	---	---	1.74
165-175	DM	Moist, dark brown clay with sand	CH	1.62	67.3	72.3	31.1	41.2	2.58	0.5	14.5	60.0	25.0	1.0	1.5	2.5	9.5	1.68
175-185	DM	Moist, dark brown clay with sand	CH	1.64	63.8	69.3	29.0	40.3	2.59	1.0	14.0	63.0	22.0	1.0	3.0	3.0	7.0	1.59
185-190	DM	Moist, dark brown clay with sand	---	1.63	64.3	---	---	---	---	---	---	---	---	---	---	---	---	1.62
190-200	DM	Moist, dark brown clay with sand	---	1.64	64.9	---	---	---	---	---	---	---	---	---	---	---	---	1.61
200-205	DM	Moist, dark brown clay with sand	---	1.87	36.3	---	---	---	---	---	---	---	---	---	---	---	---	0.90
205-215	DM	Moist, dark brown clay with sand	CH	1.70	51.0	65.4	29.3	36.0	2.61	0.5	21.5	54.0	24.0	1.0	2.5	6.0	12.0	1.31
215-225	DM	Moist, dark brown clay with sand	---	1.76	41.3	---	---	---	---	---	---	---	---	---	---	---	---	1.08
225-230	DM	Moist, dark brown clay with sand	---	1.61	56.8	---	---	---	---	---	---	---	---	---	---	---	---	1.54
230-240	DM	Moist, dark brown clay with sand	---	1.67	56.2	---	---	---	---	---	---	---	---	---	---	---	---	1.43
240-245	DM	Moist, dark brown clay with sand	---	1.68	54.0	---	---	---	---	0.0	38.5	46.5	15.0	0.5	5.5	14.0	18.5	1.38
245-255	DM	Moist, dark brown clay with sand	---	1.68	56.1	---	---	---	---	0.0	46.5	37.5	16.0	1.0	9.0	20.0	16.5	1.42
255-262	DM	Moist, dark brown clay with sand	---	1.64	59.9	---	---	---	---	---	---	---	---	---	---	---	---	1.53
262-270	DM	Moist, dark brown clay with sand	---	1.63	60.6	---	---	---	---	---	---	---	---	---	---	---	---	1.57
270-275	DM	Moist, dark brown clay with sand	---	1.64	62.1	---	---	---	---	---	---	---	---	---	---	---	---	1.58

Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Sand Components % Coarse	% Medium	% Fine	% Very Fine	Void Ratio
0-30	Cap	Moist, brown sand	---	1.82	19.3	---	---	---	---	---	---	---	---	---	---	---	---	0.7
30-60	Cap	Moist, brown sand	---	1.88	18.5	---	---	---	---	---	---	---	---	---	---	---	---	0.6
60-90	Cap	Moist, brown sand	---	1.91	18.8	---	---	---	---	---	---	---	---	---	---	---	---	0.6
90-120	Cap	Moist, brown sand	---	1.83	18.4	---	---	---	---	---	---	---	---	---	---	---	---	0.7
120-135	Cap	Moist, brown sand	SP	1.84	18.6	---	---	---	---	7.0	92.0	1.0		22.0	42.0	24.0	4.0	0.7
135-152	---	Moist, brown sand	SP	---	---	---	---	---	---	8.0	91.0	1.0		22.0	38.0	28.0	3.0	---
152-160	DM	Moist, dark brown clay with sand	---	1.56	72.1	---	---	---	---	---	---	---	---	---	---	---	---	1.86
160-170	DM	Moist, dark brown clay with sand	CH	1.60	52.7	69.5	31.6	37.9	2.55	1.5	26.5	48.0	24.0	2.0	7.5	7.0	10.0	1.49
170-180	DM	Moist, dark brown clay with sand; shell fragments	---	1.50	82.1	---	---	---	---	---	---	---	---	---	---	---	---	2.16
180-190	DM	Moist, dark brown clay with sand	---	1.56	66.4	---	---	---	---	1.5	28.0	49.5	21.0	2.0	7.5	9.0	9.5	1.78
190-195	DM	Moist, dark brown clay with sand	---	1.58	67.5	---	---	---	---	---	---	---	---	---	---	---	---	1.75
195-205	DM	Moist, dark brown clay with sand	---	1.57	67.0	---	---	---	2.62	1.0	27.0	46.0	26.0	1.0	6.0	7.0	13.0	1.76
205-220	DM	Moist, dark brown clay with sand; organics @ 216	CH	1.61	56.5	63.2	27.1	36.0	2.61	1.5	21.5	48.0	29.0	0.5	6.0	5.5	9.5	1.52
220-240	DM	Moist, dark brown clay with sand; large shell @ 235	---	1.50	75.1	---	---	---	---	---	---	---	---	---	---	---	---	2.04
240-255	DM	Moist, dark brown clay with sand	---	1.57	59.8	---	---	---	---	---	---	---	---	---	---	---	---	1.64
255-260	DM	Moist, dark brown clayey sand; small gravel	SC	1.58	52.2	45.5	20.4	25.1	---	20.0	49.0	18.0	13.0	11.5	19.5	9.0	9.0	1.50
260-269	DM	Moist, dark brown clayey sand; small gravel	---	1.75	32.7	---	---	---	---	---	---	---	---	---	---	---	---	0.97

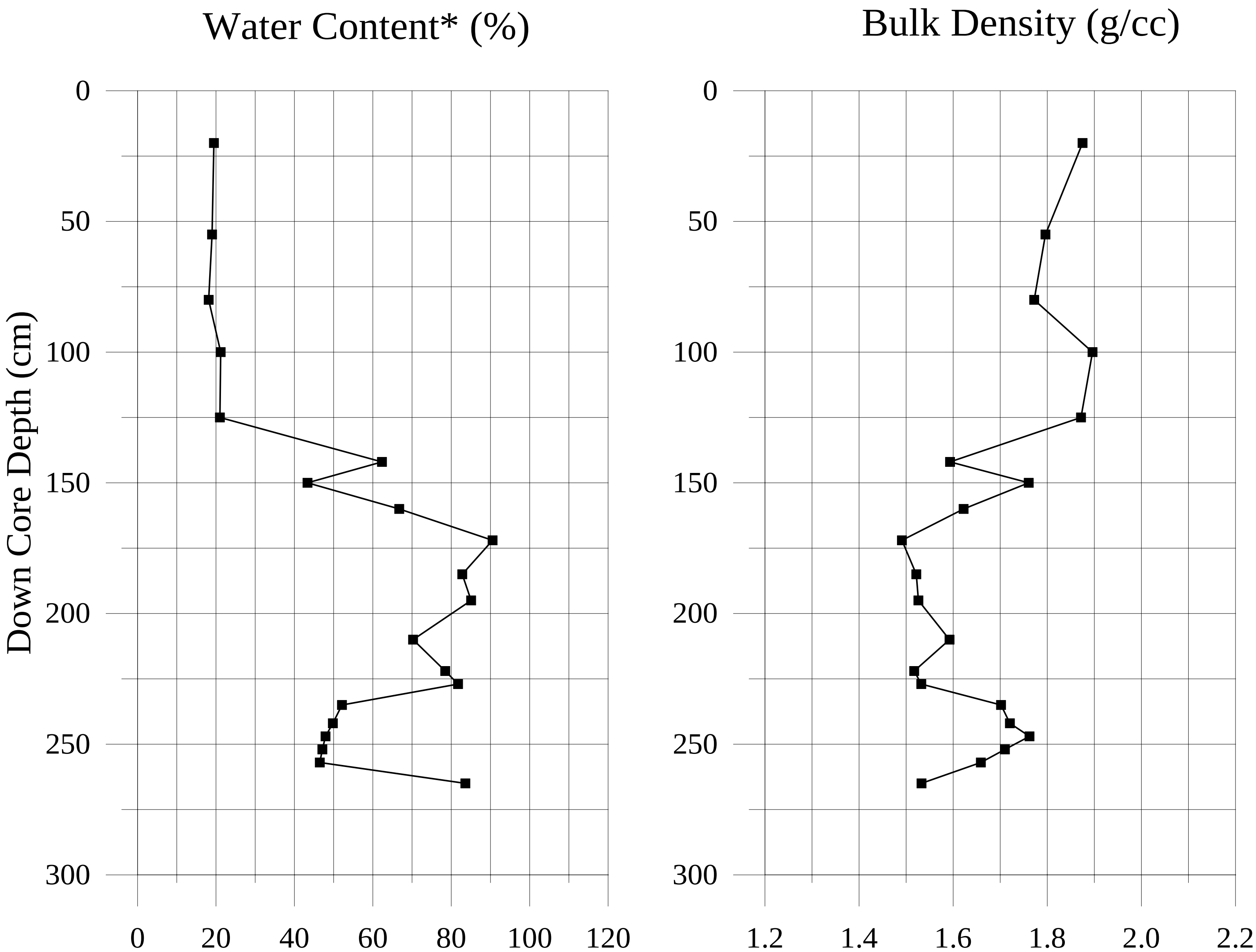
Depth (cm)	Material Unit	Physical Description (from GeoTesting Express)	USCS Symbol	Bulk Density (g/cc)	Water Content* (%)	Liquid Limit* (%)	Plastic Limit* (%)	Plasticity Index* (%)	Specific Gravity	Percent >Coarse (%)	Sand (%)	Silt (%)	Clay (%)	Sand Components % Coarse	% Medium	% Fine	% Very Fine	Void Ratio
0-40	Cap	Moist, brown sand	SP	1.85	20.7	---	---	---	---	2.5	96.5	1.0		19.0	47.5	28.0	2.0	0.7
40-70	Cap	Moist, brown sand	---	1.86	20.9	---	---	---	---	---	---	---	---	---	---	---	---	0.7
70-110	Cap	Moist, brown sand	---	1.73	17.3	---	---	---	---	---	---	---	---	---	---	---	---	0.8
110-163	Cap	Moist, brown sand; shell; dark gray silty clay vein from 152-	---	1.82	22.9	---	---	---	---	---	---	---	---	---	---	---	---	0.8
163-228	Cap	Moist, brown sand	SP	1.83	21.5	---	---	---	---	2.5	96.5	1.0		12.5	35.0	42.5	6.5	0.7

APPENDIX C
Geotechnical Profiles

Core 97A-B Geotechnical Profiles

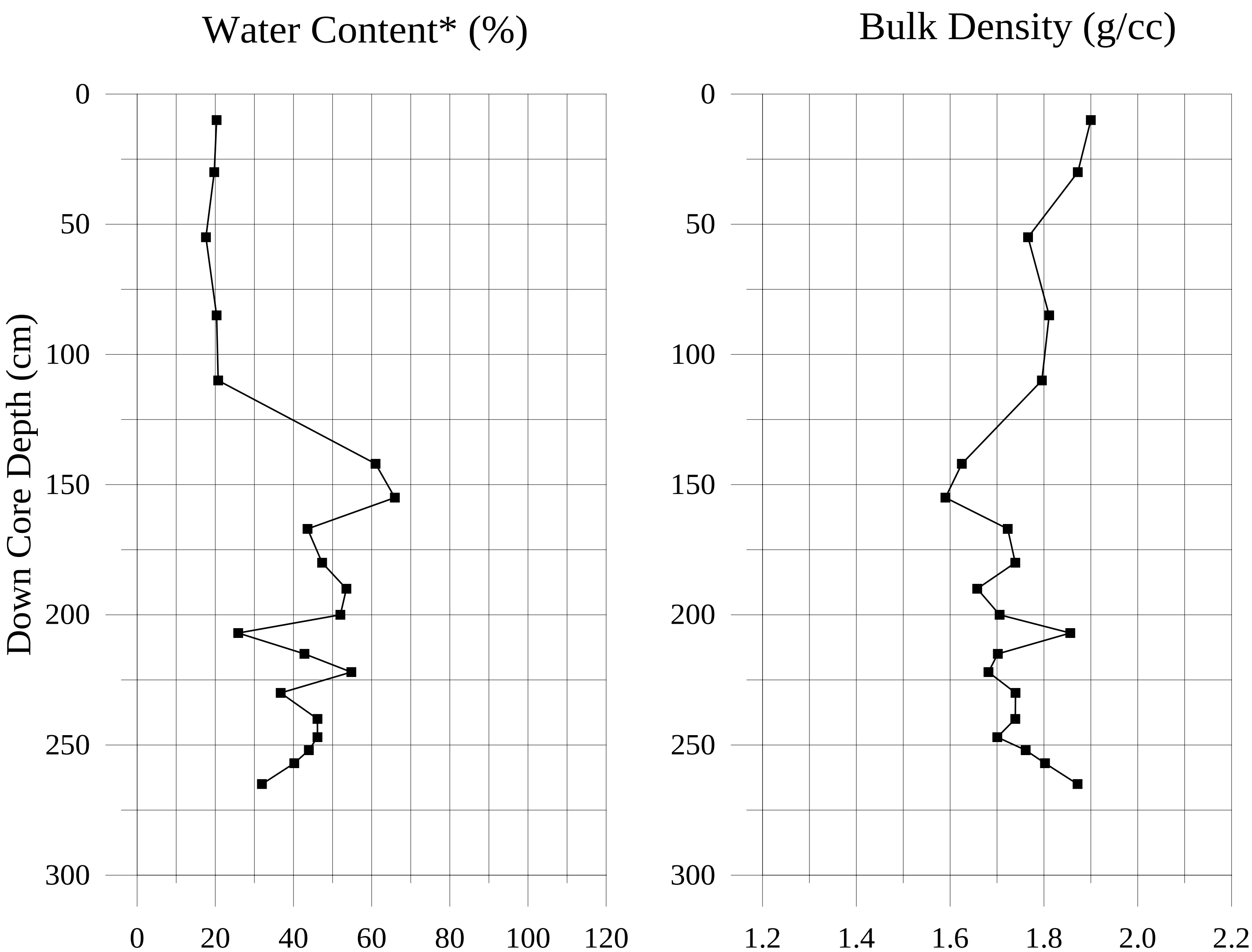


Core 97B-B Geotechnical Profiles



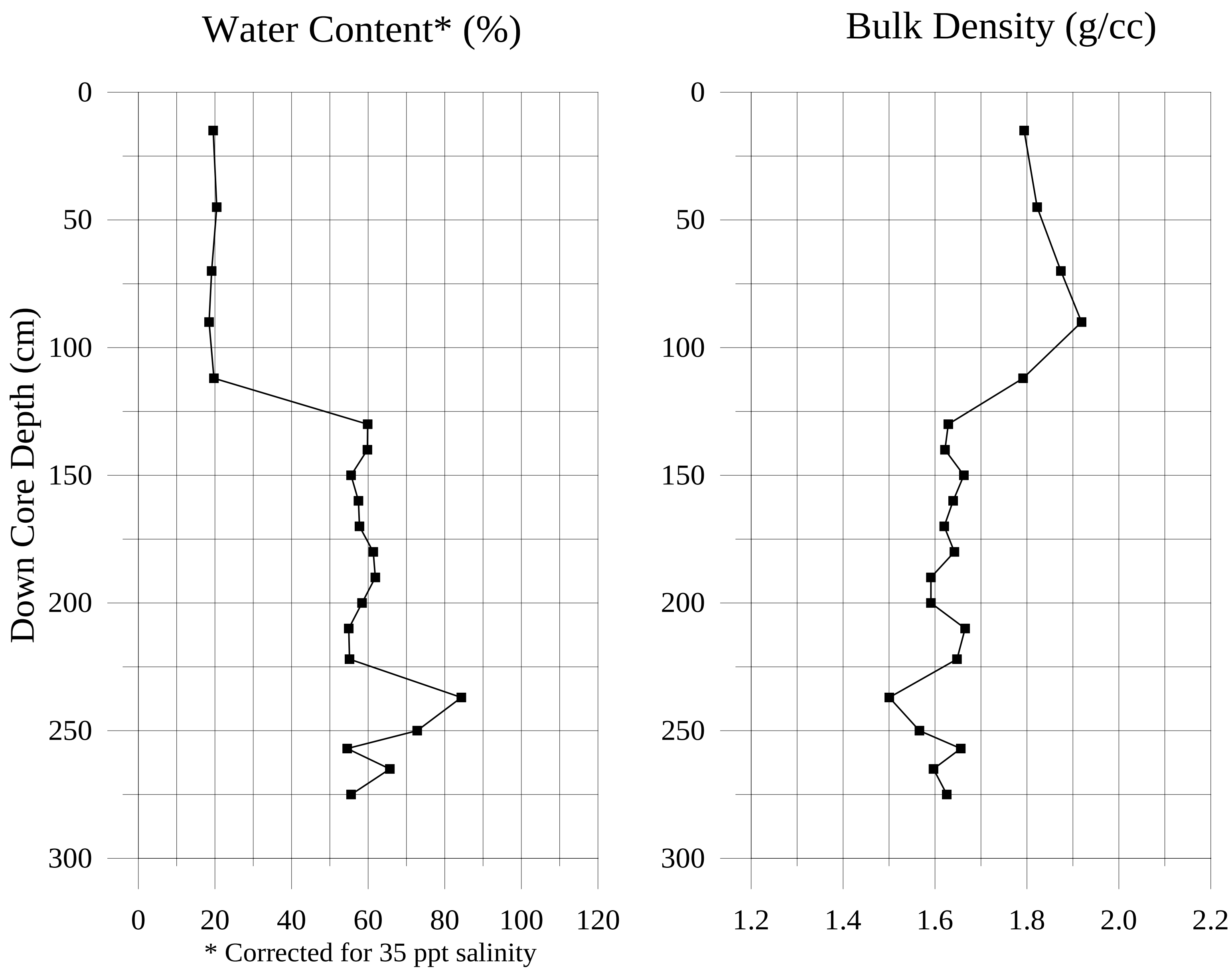
* Corrected for 35 ppt salinity

Core 97C-B Geotechnical Profiles

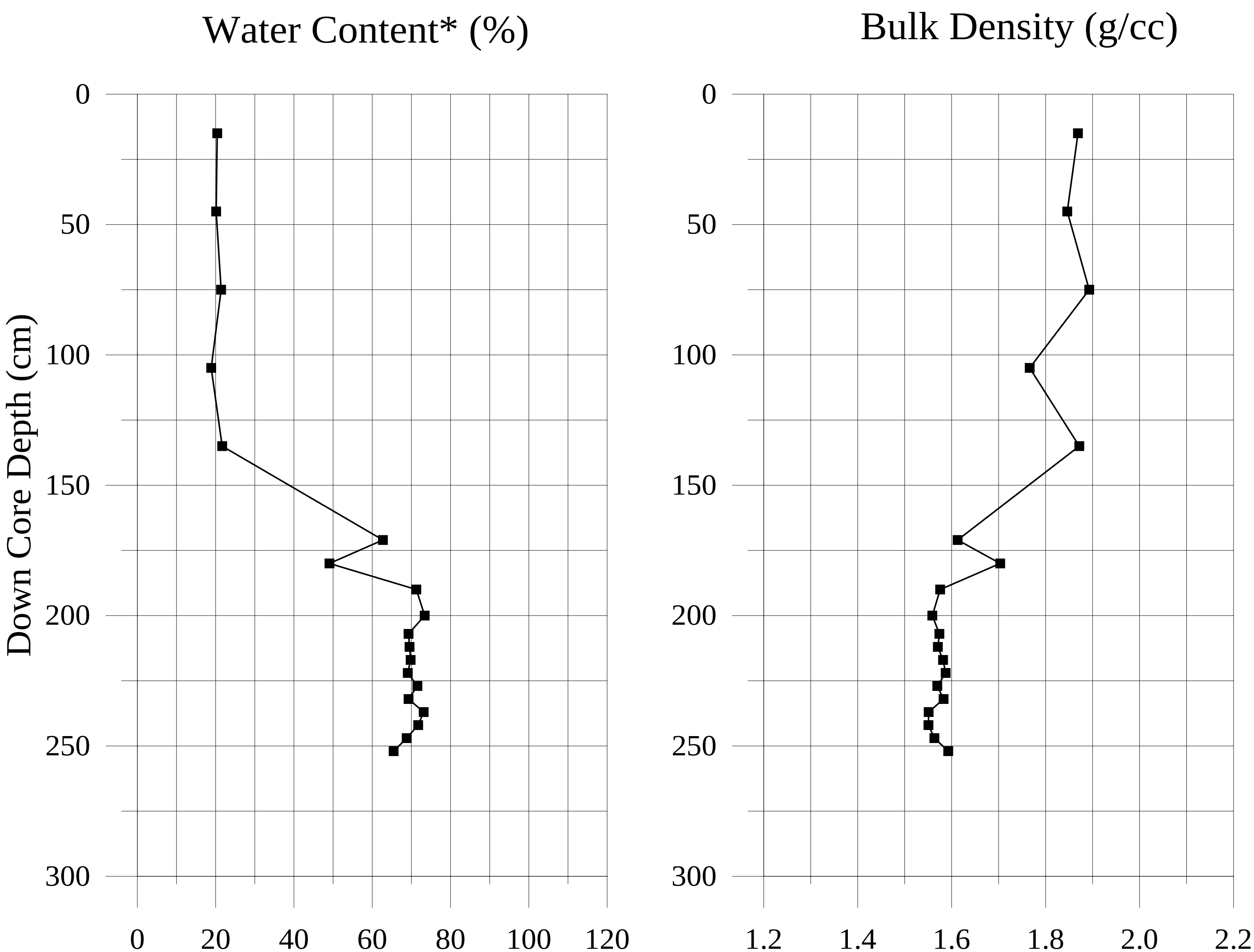


* Corrected for 35 ppt salinity

Core 97D-B Geotechnical Profiles

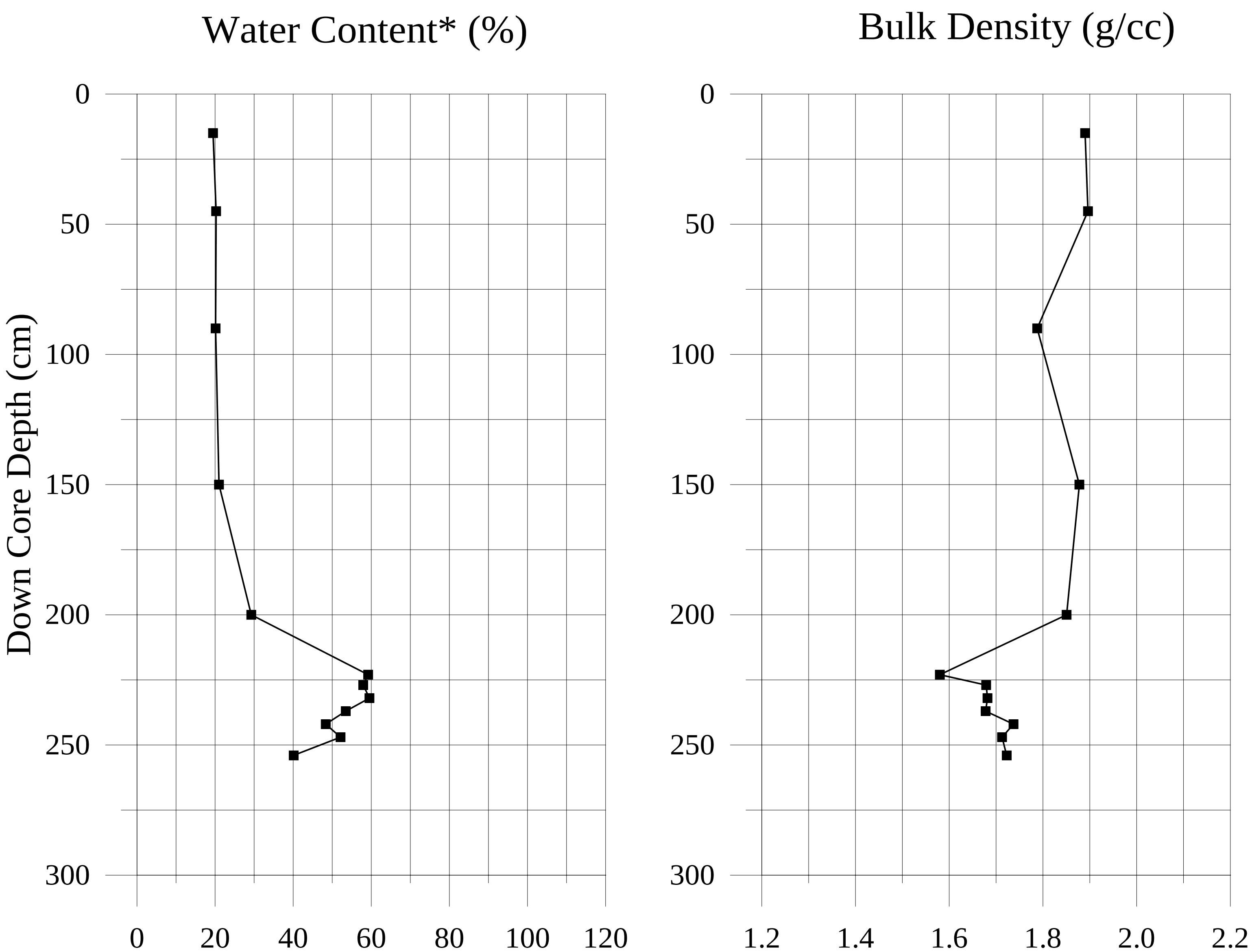


Core 97E-A Geotechnical Profiles



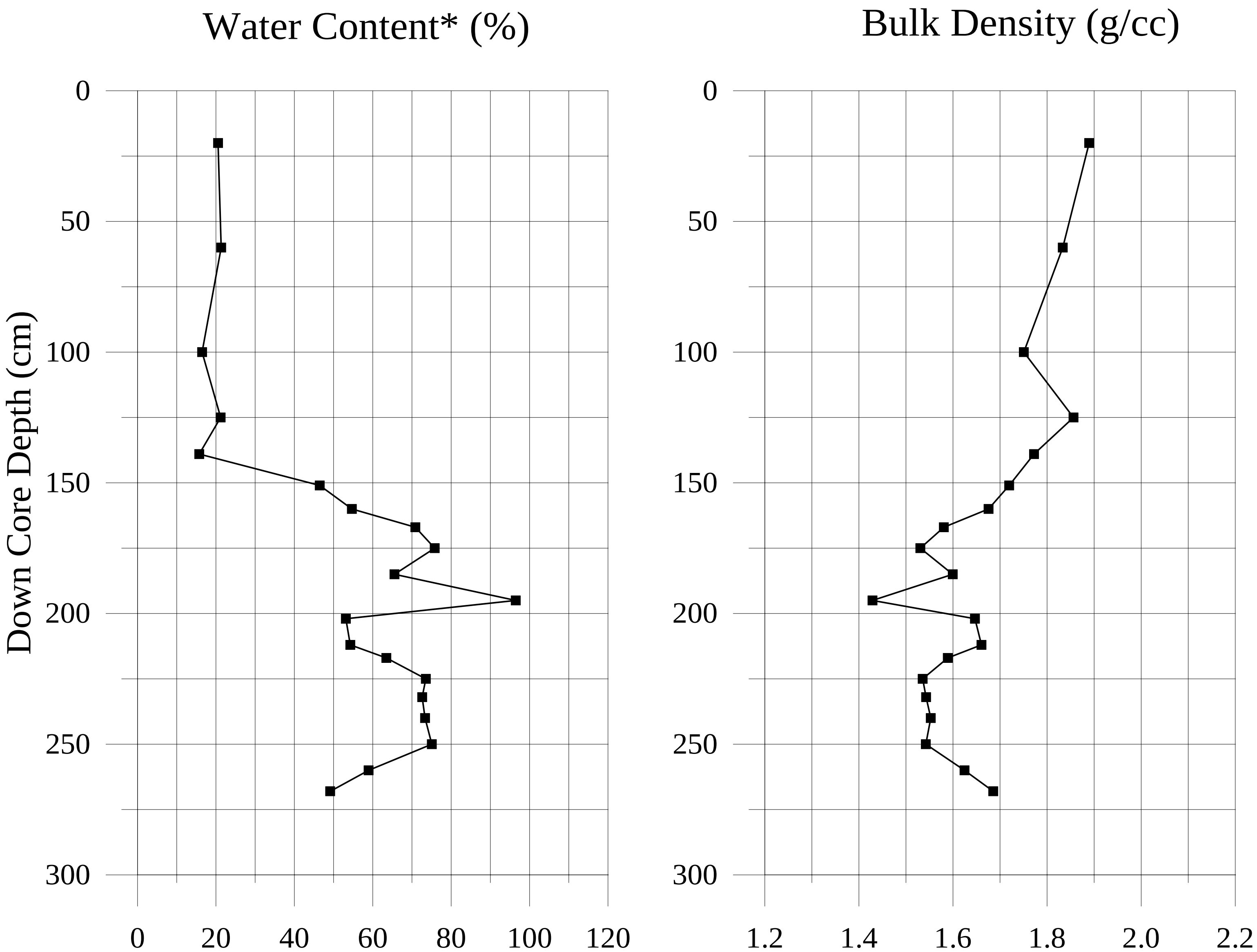
* Corrected for 35 ppt salinity

Core 97L-B Geotechnical Profiles



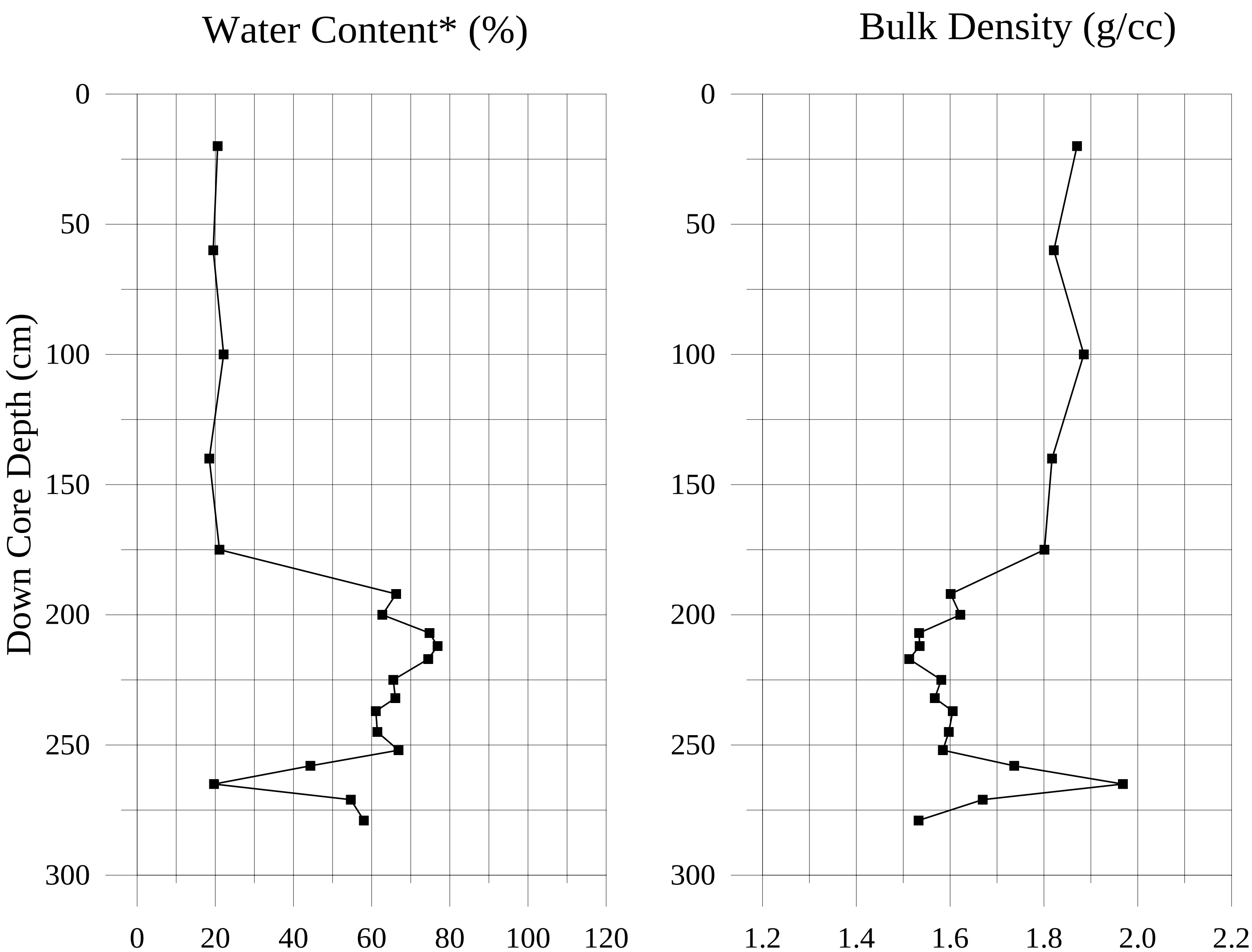
* Corrected for 35 ppt salinity

Core 97O-A Geotechnical Profiles



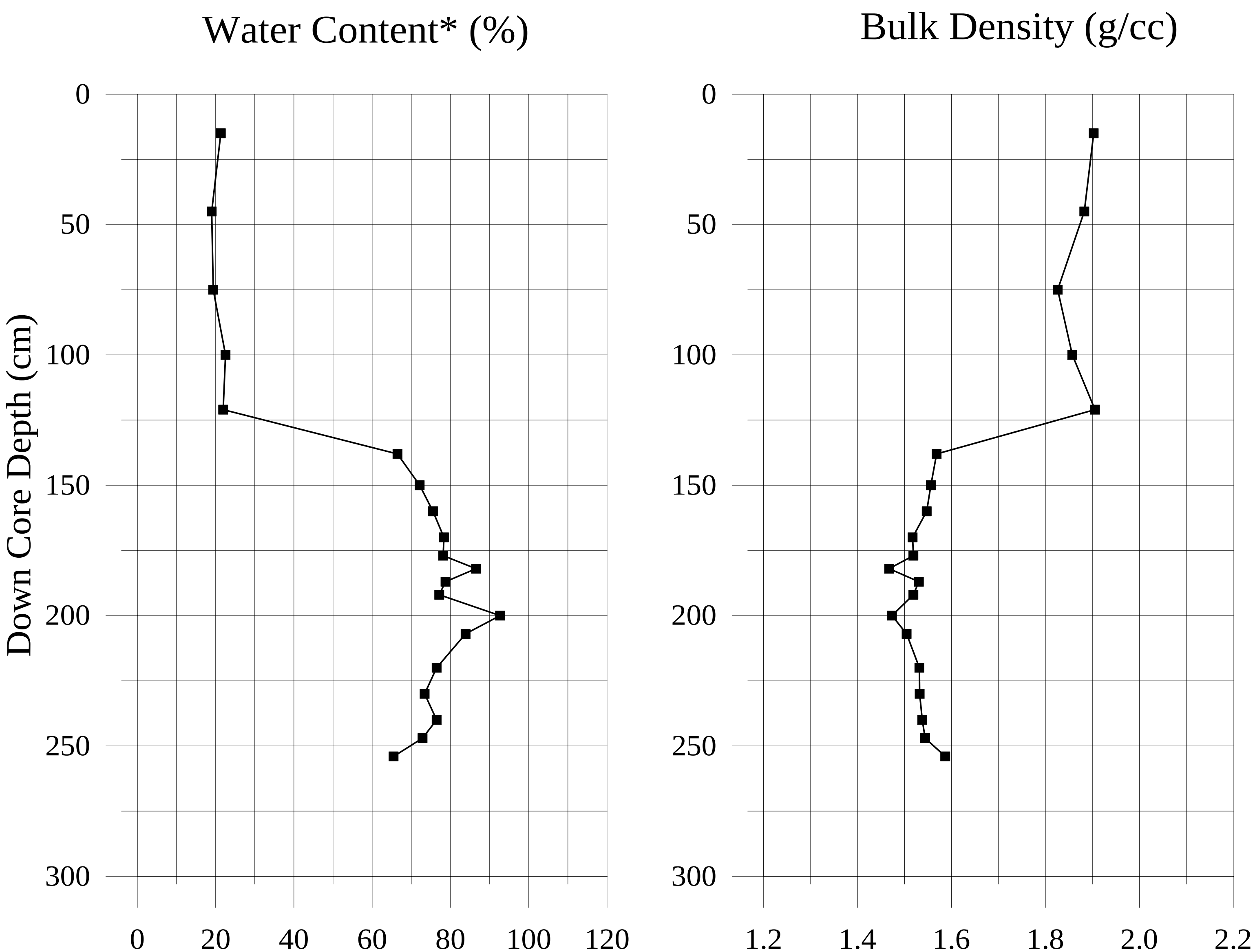
* Corrected for 35 ppt salinity

Core 97P-A Geotechnical Profiles



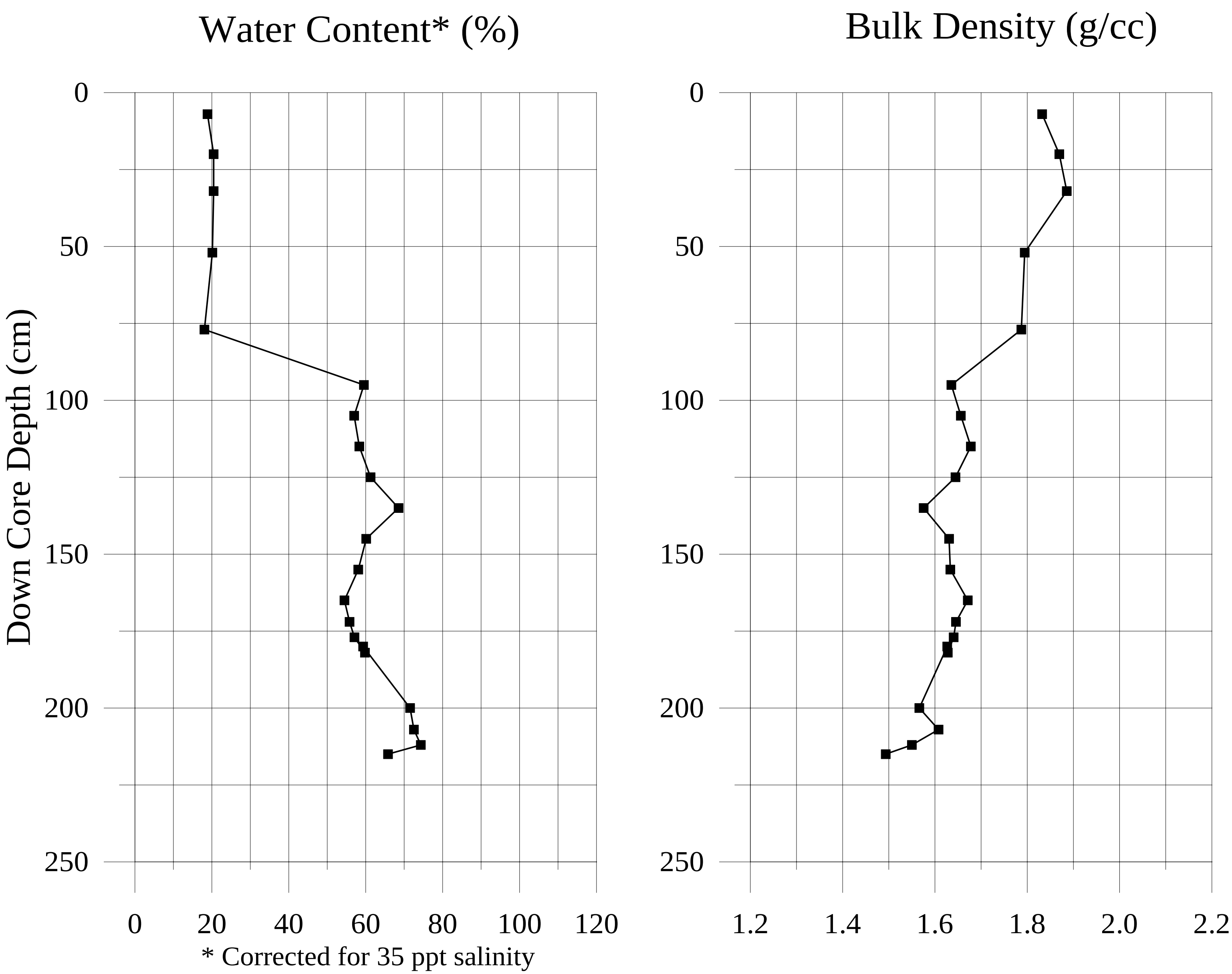
* Corrected for 35 ppt salinity

Core 97Q-A Geotechnical Profiles

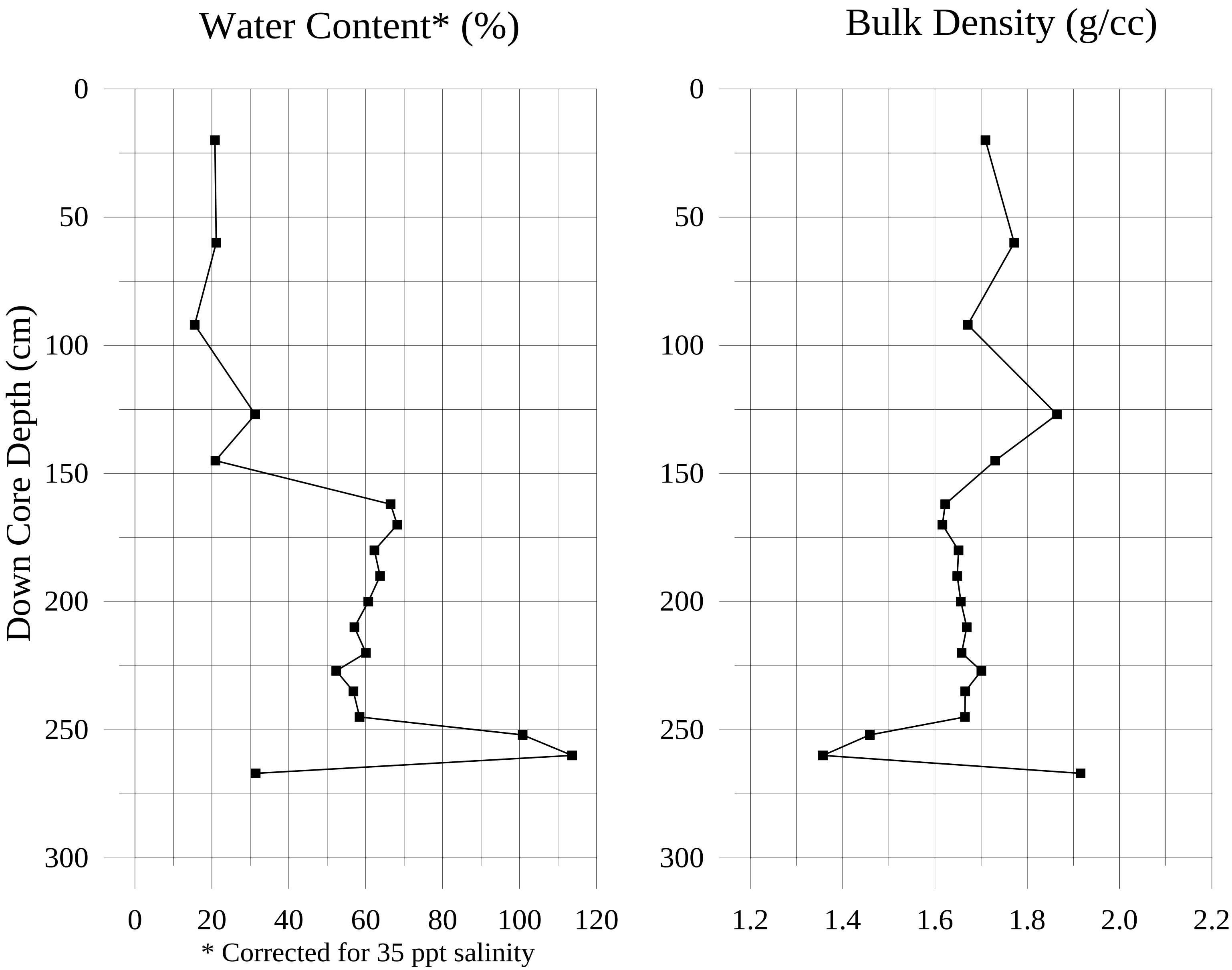


* Corrected for 35 ppt salinity

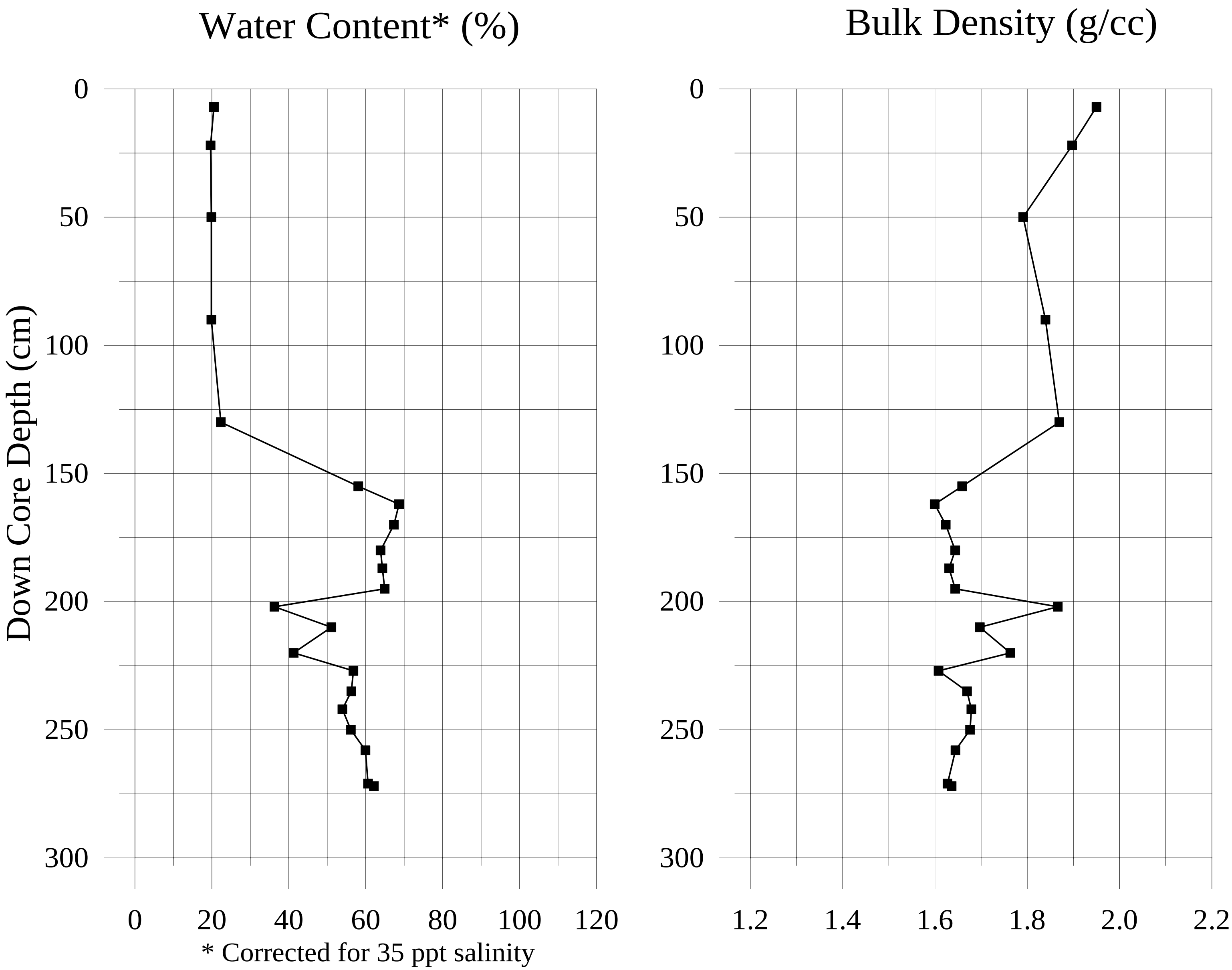
Core 97R-B Geotechnical Profiles



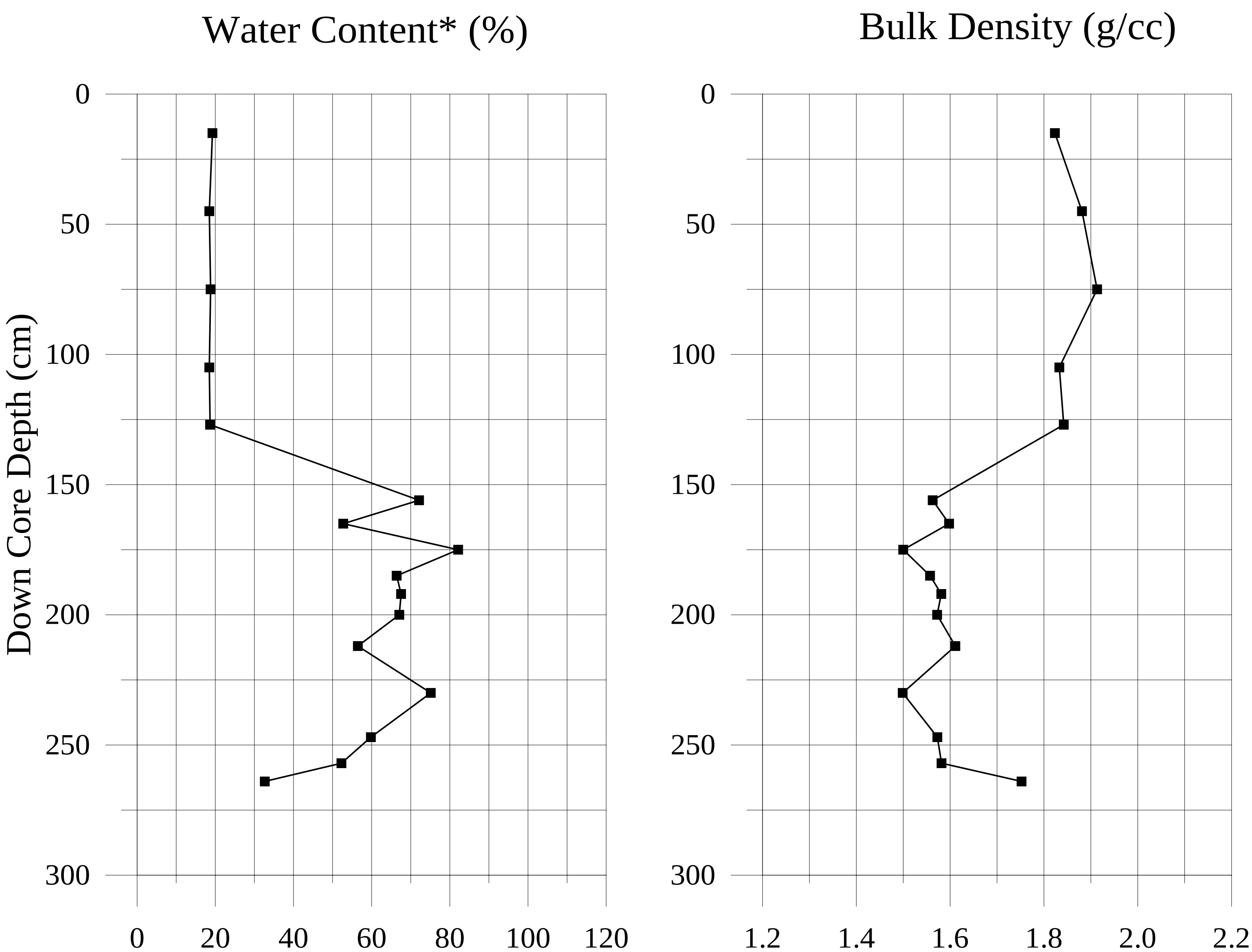
Core 97S-B Geotechnical Profiles



Core 97T-A Geotechnical Profiles

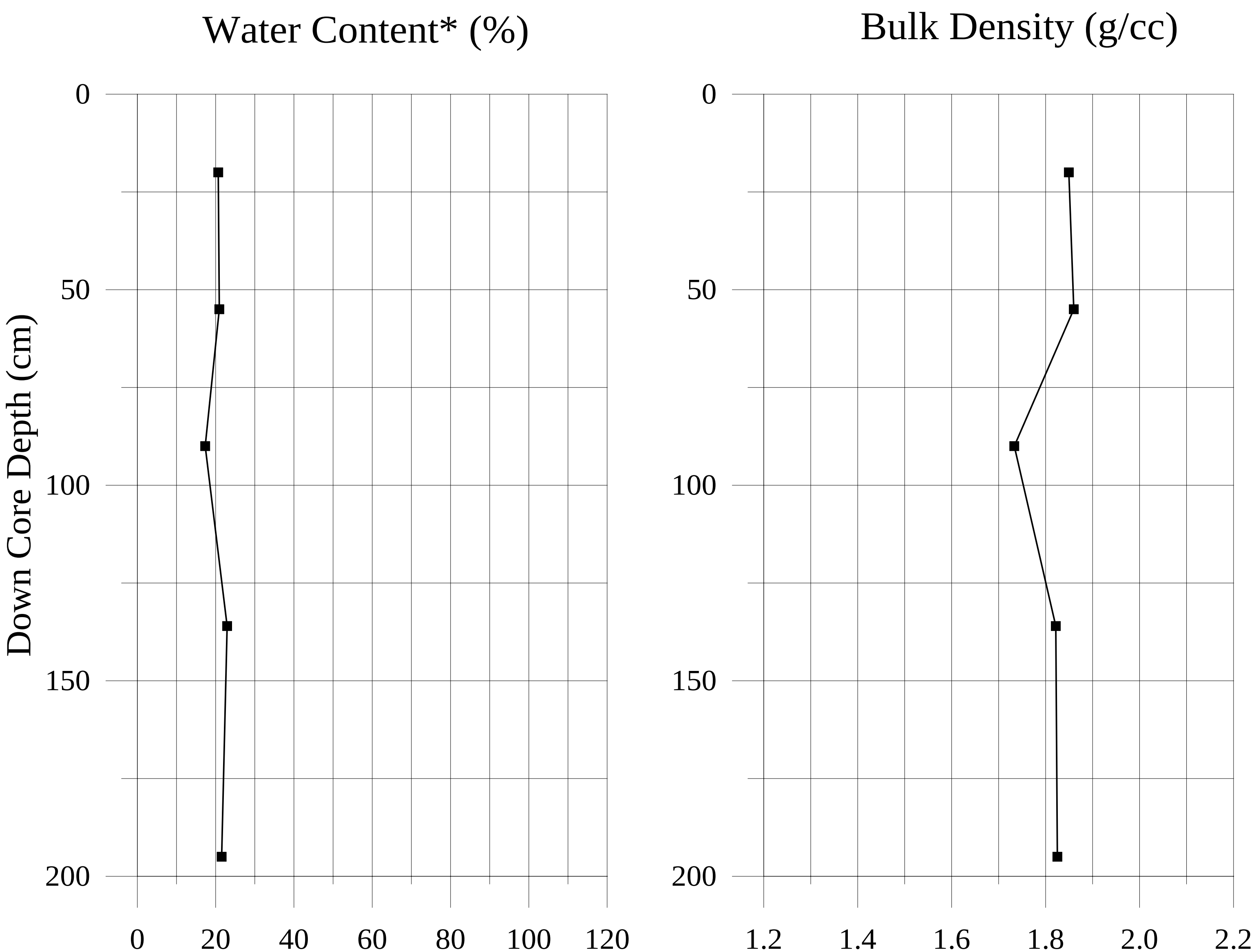


Core 97U-A Geotechnical Profiles



* Corrected for 35 ppt salinity

Core 97V-B Geotechnical Profiles



* Corrected for 35 ppt salinity

APPENDIX D
Discrete Data Chemical

Core 97B-B

	Cap		Cap		Cap		DM		DM	
†Sample Depth (cm)	110		130		138		150		170	
Concentration (pptr)										
2378-TCDF (Furan)	<0.33		<0.28		0.21	*	<0.95		<0.52	
2378-TCDD (Dioxin)	<0.30		<0.18		<0.30		1.8		0.34	
12378-PeCDF	<0.41		<0.14		<0.26		0.19		<0.45	
23478-PeCDF	<0.20		<0.11		<0.24		<0.90		<0.44	
12378-PeCDD	<0.25		<0.28		<0.17		<0.82		<1.3	
123478-HxCDF	0.19	B	0.25	B	0.22	B	1.4	B	0.57	B
123678-HxCDF	<1.6		0.23		<0.36		2.1		<2.1	
234678-HxCDF	0.34		0.30		0.35		0.62		<0.71	
123789-HxCDF	<0.27		<0.39		<0.14		<1.2		<0.71	
123478-HxCDD	<0.17		<0.21		<0.23		<0.78		0.41	
123678-HxCDD	<0.31		<0.18		<0.17		<1.2		0.61	
123789-HxCDD	<0.28		<0.13		<0.20		<0.73		0.86	
1234678-HpCDF	<0.33		<0.28		0.47		4.9		1.6	
1234789-HpCDF	<0.32		<0.48		<0.24		<1.2		<0.90	
1234678-HpCDD	0.96		0.70		1.7		11		22	
OCDF	<0.40		<0.35		0.90	B	14		1.9	B
OCDD	5.8	B	5.0	B	20		200		710	
TEC	0.49		0.34		0.44		3.3		2.2	

†Sample depth below sediment surface.

* Value may include contributions from other TCDF isomers.

All values are expressed on a dry weight basis.

B = Less than 5 times higher than method blank level

Data below detection are reported as less than (<) the detection limit.

Core 97C-A

	Cap	Cap	DM	DM	DM
†Sample Depth (cm)	104	124	144	164	184
Concentration (pptr)					
2378-TCDF (Furan)	0.37 *	<0.26	<0.15	<0.54	4.1
2378-TCDD (Dioxin)	<0.42	<0.46	<0.38	<0.69	3.3
12378-PeCDF	<0.30	<0.22	<1.0	<0.57	1.9
23478-PeCDF	<0.30	<0.19	<1.2	<0.81	2.4
12378-PeCDD	<0.39	<0.39	<0.49	<0.95	<0.90
123478-HxCDF	0.33 B	<0.67	<0.95	<0.53	2.6
123678-HxCDF	<0.23	<0.46	<0.68	<0.58	1.0
234678-HxCDF	0.41	<0.42	<0.77	0.93	1.1
123789-HxCDF	<0.34	<0.30	<0.59	<0.77	<1.0
123478-HxCDD	<0.35	<0.28	<0.70	<0.88	0.53
123678-HxCDD	<0.30	<0.41	<1.2	<0.97	1.7
123789-HxCDD	<0.23	<0.28	<1.4	<0.52	1.2
1234678-HpCDF	0.68	<0.65	2.1	1.1	10
1234789-HpCDF	<0.40	<0.90	<0.92	<1.2	<0.96
1234678-HpCDD	1.8	0.96	15	4.3	28
OCDF	1.2 B	0.51 B	5.3	2.1 B	18
OCDD	14 B	12	570	130	720
TEC	0.62	0.56	1.3	1.3	7.2

†Sample depth below sediment surface.

* Value may include contributions from other TCDF isomers.

All values are expressed on a dry weight basis.

B = Less than 5 times higher than method blank level

Data below detection are reported as less than (<) the detection limit.

Core 97E-A

	Cap	Cap		DM		DM
†Sample Depth (cm)	138	158		178		198
Concentration (pptr)						
2378-TCDF (Furan)	<1.2	<0.51		0.72	*	<1.1
2378-TCDD (Dioxin)	<1.3	<0.41		1.7		<0.54
12378-PeCDF	<1.2	<0.38		0.27		<1.0
23478-PeCDF	<1.1	<0.63		0.27		<0.85
12378-PeCDD	<2.0	<1.0		<1.3		<0.73
123478-HxCDF	<0.97	<0.77		0.9		<0.65
123678-HxCDF	<0.75	<1.3		0.84		<1.3
234678-HxCDF	<1.0	0.34	B	0.46	B	<1.5
123789-HxCDF	<0.94	<0.85		<0.83		<1.0
123478-HxCDD	<1.9	<0.54		<0.73		<1.6
123678-HxCDD	<1.0	<0.72		0.87		<1.6
123789-HxCDD	<1.2	<0.49		0.87		<1.2
1234678-HpCDF	<1.9	<0.46		4.1		<2.3
1234789-HpCDF	<2.4	<0.73		0.22		<1.6
1234678-HpCDD	<2.5	1.4		18		1.1
OCDF	<4.5	<1.9		11		<5.2
OCDD	5.9	13		490		69
TEC	1.9	0.95		1.8		1.3

†Sample depth below sediment surface.
* Value may include contributions from other TCDF isomers.
All values are expressed on a dry weight basis.
B = Less than 5 times higher than method blank level
Data below detection are reported as less than (<) the detection limit.

Core 97Q-A

	Cap	Cap	Cap	DM	DM
†Sample Depth (cm)	102	122	129	142	162
Concentration (pptr)					
2378-TCDF (Furan)	<1.8	<0.70	<0.63	0.61 *	0.24 *
2378-TCDD (Dioxin)	<1.3	<0.47	<0.54	0.89	0.15
12378-PeCDF	<0.74	<0.28	<0.59	<0.48	<0.34
23478-PeCDF	<0.66	<0.32	<0.83	0.64	<0.50
12378-PeCDD	<2.4	<0.60	<0.37	<0.95	<0.14
123478-HxCDF	<0.66	<0.50	<0.69	<2.10	<0.48
123678-HxCDF	<0.59	<0.11	<1.6	0.43	<0.58
234678-HxCDF	<1.5	0.44	<0.36	0.90 B	<0.63
123789-HxCDF	<1.7	<0.20	<0.51	<0.57	<0.99
123478-HxCDD	<1.6	<0.53	<0.29	<0.61	<0.68
123678-HxCDD	<1.3	<0.35	<0.77	0.91	<0.51
123789-HxCDD	<0.90	<0.24	<0.30	<0.94	<0.74
1234678-HpCDF	<1.4	0.63	<0.67	4.4	<1.4
1234789-HpCDF	<1.6	<0.32	<0.62	<0.84	<1.2
1234678-HpCDD	3.7	2.5	0.45 B	22	1.8
OCDF	<2.0	2.5 B	0.51	7.5	<1.8
OCDD	32	22	11	740	38
TEC	2.0	0.70	0.86	3.0	0.64

†Sample depth below sediment surface.
* Value may include contributions from other TCDF isomers.
All values are expressed on a dry weight basis.
B = Less than 5 times higher than method blank level
Data below detection are reported as less than (<) the detection limit.

Core 97R-B

	Cap	Cap	DM	DM	DM	DM
†Sample Depth (cm)	62	82	102	122	142	162
Concentration (pptr)						
2378-TCDF (Furan)	<0.98	<0.68	0.83 *	<1.0	<1.1	1.0 *
2378-TCDD (Dioxin)	<0.95	<0.92	1.9	1.7	<3.1 I	1.5
12378-PeCDF	<0.45	<0.57	<1.0	<1.8	<1.7	0.54
23478-PeCDF	<0.65	<0.60	<3.9	<2.5	<1.2	0.46
12378-PeCDD	<0.58	<0.48	<1.1	<1.9	<2.2	<0.55
123478-HxCDF	<0.61	<0.67	<2.0	<1.2	2.5	<2.6
123678-HxCDF	<0.86	<0.64	<1.1	<1.8	<1.2	0.68
234678-HxCDF	<0.51	<1.0	0.98	1.1	1.3	1.0 B
123789-HxCDF	<0.57	<0.77	<1.3	<1.4	<1.4	<0.41
123478-HxCDD	<0.79	<0.76	<1.7	<1.3	<0.99	<0.65
123678-HxCDD	<0.51	<0.42	<1.5	<2.1	<1.7	1.1
123789-HxCDD	<0.43	<0.50	<2.6	<1.9	<1.8	0.82
1234678-HpCDF	<0.75	<0.70	9.7	8.7	6.8	6.5
1234789-HpCDF	<0.45	<0.87	<2.2	<2.0	<1.4	<0.73
1234678-HpCDD	<2.0	<2.4	19	23	26	17
OCDF	<1.2	<2.2	15	13	14	11
OCDD	5.3	4.2	640	650	800	460
TEC	1.1	1.0	4.8	4.5	4.4	3.2

†Sample depth below sediment surface.
* Value may include contributions from other TCDF isomers.
All values are expressed on a dry weight basis.
B = Less than 5 times higher than method blank level
I = Interference
Data below detection are reported as less than (<) the detection limit.

Core 97U-A

	Cap	Cap	DM	DM	DM
[†]Sample Depth (cm)	121	141	161	181	201
Concentration (pptr)					
2378-TCDF (Furan)	<0.55	0.35 *	1.6	3.2	2.4
2378-TCDD (Dioxin)	<0.76	<0.39	2.6	1.4	7.0
12378-PeCDF	<0.24	<0.30	1.2	3.6	<4.9
23478-PeCDF	<0.61	<0.26	1.6	<3.8	<5.7
12378-PeCDD	<0.61	<0.67	<1.0	<4.6	<6.5
123478-HxCDF	<0.42	<0.40	3.5	4.2	<8.8
123678-HxCDF	<0.31	<0.33	1.7	4.4	<3.5
234678-HxCDF	0.39	0.34	2.0	3.4	<7.2
123789-HxCDF	<0.56	<0.40	<1.1	<6.6	<5.4
123478-HxCDD	<0.62	<0.69	0.57	<4.4	<4.3
123678-HxCDD	<0.73	<0.45	1.9	<3.7	<4.9
123789-HxCDD	<0.54	<0.52	1.5	<5.0	<5.1
1234678-HpCDF	<0.61	<0.33	14	25	35
1234789-HpCDF	<0.45	<0.47	1.3	<12	<7.9
1234678-HpCDD	0.87	0.89	27	28	52
OCDF	<1.2	<0.53	20	29	47
OCDD	4.8 B	7.1 B	640	880	890
TEC	0.94	0.66	6.1	7.7	14

[†]Sample depth below sediment surface.

* Value may include contributions from other TCDF isomers.

All values are expressed on a dry weight basis.

B = Less than 5 times higher than method blank level

Data below detection are reported as less than (<) the detection limit.

Grain Size Scale for Sediments

U. S. Standard Sieve Mesh #		Millimeters	Microns	Phi (ϕ)	Wentworth Size Class	
		(1 Kilometer)		-20		
		4096		-12		GRAVEL
		1024		-10	Boulder (-8 to -12ϕ)	
Use		256		-8		
wire		64		-6	Cobble (-6 to -8ϕ)	
squares		16		-4	Pebble (-2 to -6ϕ)	
5		4		-2		
6		3.36		-1.75		
7		2.83		-1.5	Granule	
8		2.38		-1.25		
10		2.00		-1.0		
12		1.68		-0.75		SAND
14		1.41		-0.5	Very coarse sand	
16		1.19		-0.25		
18		1.00		0.0		
20		0.84		0.25		
25		0.71		0.5	Coarse sand	
30		0.59		0.75		
35	1/2	0.50	500	1.0		
40		0.42	420	1.25		
45		0.35	350	1.5	Medium sand	
50		0.30	300	1.75		
60	1/4	0.25	250	2.0		
70		0.210	210	2.25		
80		0.177	177	2.5	Fine sand	
100		0.149	149	2,75		
120	1/8	0.125	125	3.0		
140		0.105	105	3.25		
170		0.088	88	3.5	Very fine sand	
200		0.074	74	3.75		
230	1/16	0.0625	62.5	4.0		
270		0.053	53	4.25		MUD
325		0.044	44	4.5	Coarse silt	
		0.037	37	4.75		
	1/32	0.031	31	5.0		
Analyzed	1/64	0.0156	15.6	6.0	Medium silt	
	1/128	0.0078	7.8	7.0	Fine silt	
by	1/256	0.0039	3.9	8.0	Very fine silt	
		0.0020	2.0	9.0		
Pipette		0.00098	0.98	10.0	Clay	
		0.00049	0.49	11.0	(Some use 2μ or	
or		0.00024	0.24	12.0	9ϕ as the clay	
		0.00012	0.12	13.0	boundry)	
		0.00006	0.06	14.0		
Hydrometer						